BASIC BLUEPRINT READING AND SKETCHING

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BASIC

BLUEPRINT READING AND SKETCHING

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Related Series

BASIC BLUEPRINT READING AND SKETCHING

A new, practical basic text and work book in which the principles of reading and interpreting blueprints and techniques of making shop sketches are applied to actual industrial parts.

Contents: Part One, Section I - Lines, II - Views, III - Dimensions and Notes, IV - Sections. Part Two covers principles and applications of shop sketching. Each instructional unit includes: (a) Related Technical Information, (b) Shop Blueprints and (c) Assignment Sheets. - - - - 160 pages, with 40 industrial blueprints and sketches

ADVANCED BLUEPRINT READING, Volume I

An intermediate text and work book for those who have a basic understanding of blueprint reading. The series of folded-in full sized blueprints were selected for design features, methods of representation and unusual applications of drafting principles.

Contents: 25 instructional units containing: (a) Basic Trade Theory, (b) Accompanying Industrial Blueprints, and (c) The Assignment Sheet. Includes sketches, auxiliary sections, distorted views, representation of common machining and manufacturing processes and other advanced principles of drafting and design. - - 113 pages + 25 folded-in blueprints.

ADVANCED BLUEPRINT READING, Volume II

An advanced student text and work book dealing with the representation of complex parts and mechanisms and the interpretation of shop prints for special features of design, fabrication, construction and assembly. This text covers distorted, aligned and preferred methods of projection; design, function and operation of jigs and fixtures; gearing; assembly drawings.

MATHEMATICS FOR BEGINNERS

A practical student text and work book dealing with basic mathematical principles and their applications in the Metal Trades in solving every-day shop problems.

Contents: Common and decimal fractions, direct measurement with instruments, symbolism, equations, exponents, the formula, ratio and proportion, relationships, indirect measurement applying concepts of geometry and right triangle trigonometry. - - - 171 pages, abundant problem material

DRAFTING SIMPLIFIED

A new, comprehensive text which completely covers the field of drafting. New material is presented through clear, illustrated information sheets. Application is provided through definite assignment drawings and step-by-step instruction.

Contents: Drafting Tools - Lettering - Two and Three View Working Drawings - Auxiliary Views - Revolution - Screw Threads, Bolts, Nuts - Machine Details - Geometric Constructions - Parallel Line and Radial Line Developments - Triangulation - Isometric Drawing - Oblique Drawing - Perspective Drawing - Sketching - Reference Tables and Index. - - 408 pages, profusely illustrated, includes assignment and problem material

Preface

Blueprints are the guideposts of industry. By their use, both simple and complex parts and mechanisms may be described graphically with such completeness that one part, or any number of the same part, may be manufactured to the specified size, shape and degree of accuracy. The blueprint points the way at each stage of production from the time an original idea is conceived until the product is completed.

If it were possible to accumulate all blueprints over a long period of years they would furnish an accurate inventory of manufactured articles and the newer experimental projects. These, in turn, would become a partial historical record of man's achievements and civilization's progress.

They would tell another story, too, about inter-country dependence and cooperation, since the blueprint is the universal language of craftsmen. While languages and systems of measurement vary among the various countries of the world, certain drafting techniques are recognized as standard. Thus, it is possible for craftsmen, who can interpret drawings, to produce identical parts even though they work in different lands. This universal language forms the foundation for the production of interchangeable parts.

Because techniques of representation differ with manufacturers, careful analyses of drafting room practices and occupational studies were made to determine the blueprint reading needs of skilled and semi-skilled workers. These comparative studies of training needs gave direction and emphasized the degree of thoroughness with which each instructional unit had to be organized and written.

The scope of instructional units in this book is sufficiently broad to insure complete mastery in blueprint reading and to cover the range of drawings, sketches and prints which mechanics are normally required to read and to interpret accurately. The individual units incorporate many of the newer tested teaching-learning methods and curriculum development practices which both writers have used successfully under actual conditions.

Grateful acknowledgment is made to Elmer A. Rotmans, Head of the Drafting Department, Edison Technical and Industrial High School, Rochester, for the skillful preparation of the drawings; and to Peter J. Olivo, Associate Director of Curriculum Research, Delmar Publishers, Inc., for the preparation of final manuscript for publication.

C. Thomas Olivo
Albert V. Payne

Albany, New York
December 1951

To the Instructor

Basic Blueprint Reading and Shop Sketching provides instructional material for students, apprentices, craftsmen, technicians, engineers and others who must develop the ability to read and interpret blueprints and make simple sketches.

The book is divided into two major parts. Part One covers the basic principles of blueprint reading and the application of each new principle. Part Two deals with techniques of making shop sketches without the use of instruments. In both parts, the instructional units are arranged in a natural sequence of teaching-learning difficulty.

In each part, the units are grouped in sections. Part One begins with an Introduction to Blueprint Reading followed by Section 1 on Lines, Section 2 on Views, Section 3, Dimensions and Notes, and Section 4, Sections. In Part Two, all of the units are in Section 5 on Shop Sketching.

Each instructional unit includes a Basic Principle Series, a Blueprint Series and an Assignment Series. A brief description of each series follows.

BASIC PRINCIPLE SERIES

In the Basic Principle Series, drafting principles and concepts and all the related technical information necessary to interpret each new item on a drawing are described in detail. Trade terminology and shop practices are defined and applied in operational notes, which appear on drawings. The topics in this series are arranged in the logical order of dependence of one basic principle on the next.

The teaching of the basic principles in the first two sections may be simplified by using a projection box as a training aid. If the sides of the projection box are made of a clear plastic on which chalk may be used, this newer material makes it easier to erase lines than the old type wire-screen projection box. The use of colored chalk against lighted plastic panels increases the effectiveness of the presentation.

BLUEPRINT SERIES

Each new basic principle is applied on one or more industrial blueprints. Certain changes have been made from the original drawings to provide a wide range of experiences through the use of different drafting techniques. Many of the shop

drawings for the beginning units have been simplified by removing the title boxes. The drawings are prepared according to latest accepted standards established by the American Standards Association.

ASSIGNMENT SERIES

In the Assignment Series, a number of problems are given to cover the application of the basic principles on the drawings in the Blueprint Series. The questions in the Assignment Series are worded in typical trade terminology and are intended to develop and test the student's ability to read shop drawings and blueprints for required dimensions, shape description, machining operations and other essential data. This is the kind of information which is needed by the worker for the layout, fabrication, construction, assembly, testing or operation of a single part or a mechanism of many parts.

Encircled letters and numbers are used throughout the Blueprint and Assignment Series to simplify the asking of questions which otherwise require lengthy descriptions and are time consuming. Sufficient repetition is provided to insure the mastery of each new basic principle.

A ruled space is included on each assignment sheet for solutions to all problem material. These spaces are arranged to conserve time in checking the accuracy of each answer.

SHOP SKETCHING

The organization of the units in this section is identical to the units in Part One. The first units cover the principles of sketching simple straight and slant lines, curved lines, circles, and rounded corners and edges. These different shapes of lines are combined in sketching more complicated parts.

Straight lettering and slant lettering, with either the right or left hand, are covered in two units as there is daily need for lettering and dimensioning. The last four units in the section deal with the techniques of making orthographic, oblique, isometric and perspective sketches.

Within each unit, a few practical, simplified techniques of sketching are described and illustrated. These are followed by a blueprint which either shows how the techniques are applied to shop sketches or furnishes information from which the student makes sketches, without the use of drafting instruments or equipment.

Contents

PART ONE

SECTION I LINES

SECTION II VIEWS

SECTION III DIMENSIONS AND NOTES

SECTION IV SECTIONS

PART TWO

SECTION V SHOP SKETCHING

APPENDIX

Basic Blueprint Reading



PART ONE

INTRODUCTION

Unit 1 BASES FOR INTERPRETING BLUEPRINTS AND SKETCHES

Technical information about the shape and construction of a simple part may be conveyed from one person to another by the spoken or written word. As the part or mechanism becomes more and more complex by the addition of details, the designer, draftsman, engineer and mechanic must use precise methods to describe the object adequately.

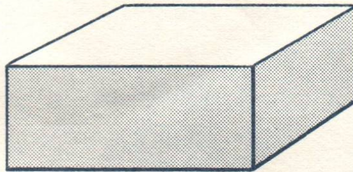


FIG. 1 A PICTURE OF A RECTANGULAR BLOCK

A picture (Fig. 1) or a photograph would help, although in neither case would the exact sizes, cut-away sections or machining operations be shown. On the other hand, the blueprint of a mechanical drawing or an accurate shop sketch meets very exacting needs for accurate description of the shape, construction and size of a part (Fig. 2).

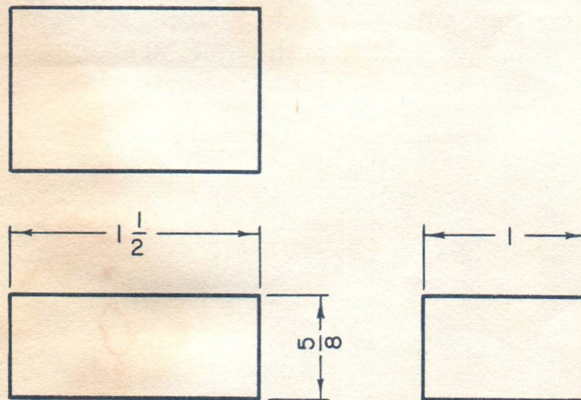


FIG. 2 MECHANICAL DRAWING OF THE RECTANGULAR BLOCK

BLUEPRINT READING, A "UNIVERSAL LANGUAGE"

Blueprints then are the universal language by which all the information the mechanic, designer and others need to know is furnished. Blueprint reading refers to the process of interpreting a print to form a mental picture of how the object looks when completed. Training in blueprint reading includes the development of the ability to visualize various manufacturing or fabricating processes required to make the part, certain basic principles underlying the use of various types of lines and views, how to apply dimensions, and how the inside of a part looks in section. The mechanic must develop an understanding of universal standards, symbols, signs and other techniques which the draftsman uses to describe a part, unit or mechanism completely. The craftsman develops some fundamental skills in making sketches so that with pencil and paper sufficient data may be recorded on the sketch relating to dimensions, notes and other details necessary for the construction of the part.

INDUSTRIAL PRACTICES RELATING TO THE USE OF DRAWINGS

In modern industrial practice, original drawings are seldom sent to the shop. Instead, exact reproductions of the original are made and the duplicate copies are distributed to all individuals, departments and plants who are responsible for planning, fabricating or assembling a part or unit. The original drawings are filed for record purposes and to protect them. Revisions and changes in design are often recorded on these drawings. A brief description of a few of the reproduction processes and kinds of prints that are found in daily use follows.

TYPES OF DUPLICATED DRAWINGS

THE BLUEPRINT

One of the oldest, and still widely used, processes of duplicating master drawings is called "blueprinting". In reproducing drawings by this method, the blueprint is made on a paper or cloth coated with an emulsion which is sensitive to light. A transparent tracing of the required drawing is placed on the sensitized paper or cloth and is exposed to a strong light which passes through the transparent tracing. The lines on the drawing hold back some of the light and leave their impression on the blueprint paper. After exposure to a light source, the sensitized paper or cloth is passed through a developer and washed with water. This blueprint, except for shrinkage during the drying process, is an exact duplicate of the original drawing.

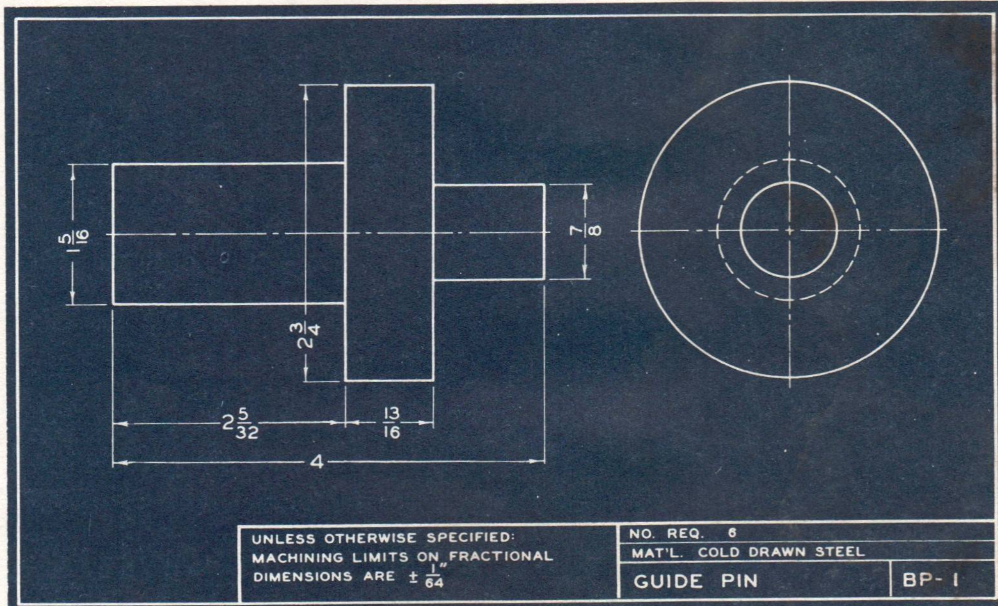


FIG. 3 SAMPLE BLUEPRINT

On the original drawing of the Guide Pin, the outlines are black or opaque on a transparent background. In the sample blueprint, Figure 3, the lines are white and the exposed background is blue.

The term "blueprint" which originally identified a blue and white reproduction is used loosely in modern industrial language to cover many different types of reproductions of mechanical drawings or freehand sketches. For example, with a patented paper called "BW paper", a reproduction with black outlines against a white background may be made.

AMMONIA PROCESS PRINTS

The ammonia process, which is another contact method of reproduction, produces a print with either blue, black or maroon lines on a white background. The color of the lines depends on the sensitized coating of the paper. In this process the sensitized paper, after exposure, is developed in a closed container which is filled with ammonia vapor.

PHOTOSTATS

Copies of drawings are sometimes made by a photographic process which does not require a transparent tracing. Instead, the copy is focused by means of photographic equipment onto a sensitized paper. The photostat, when developed, is a reverse or negative print of the copy. All lines appear white against the brownish-black background. A positive photostat with lines in black against a white background may be made from the negative photostat.

While the photostatic process of duplicating drawings is more expensive than many other methods, one advantage is in the fact that enlarged or reduced drawings may be made with little added expense.

Regardless of the method of duplicating an original drawing, the principles of graphically describing an object to furnish exact and positive information remain the same. Again, blueprint reading refers to the process of interpreting a drawing by visualizing the object clearly, accurately and with speed and skill from the information which is presented in graphic form.

ELEMENTS COMMON TO ALL DRAWINGS

A mechanical drawing, when analyzed, includes lines of different lengths and intensity. These lines, when combined with each other, define the shape, details and size of an object. The lines in turn are grouped according to the surfaces of the object being viewed in what are called "views". As a further help in describing the object, certain dimensions and notes are included on each view. Sometimes objects are cut apart by imaginary cutting planes in order to see a "sectional view" of the internal shape and construction of the part.

The fundamental principles of blueprint reading by which typical industrial drawings may be interpreted are included in the series of instructional units which follow in Section 1 on Lines; Section 2, Views; Section 3, Dimensions and Notes; and Section 4, Sections. The basic elements of making freehand sketches are covered in the series of units in Section 5.

Unit 2 THE ALPHABET OF LINES - OBJECT LINES

The line is the basis of all industrial drawings. By combining lines of different thicknesses, types and lengths, it is possible to graphically describe any object in sufficient detail so that a craftsman with a basic understanding of blueprint reading can accurately visualize the shape of the part.

THE "ALPHABET OF LINES"

During comparatively recent years, the American Standards Association has adopted and recommended certain drafting techniques and standards for lines. The types of lines commonly found on drawings are known as the "alphabet of lines". The six lines which are most widely used from this alphabet include: (1) object lines, (2) hidden lines, (3) center lines, (4) extension lines, (5) dimension lines and (6) projection lines. A brief description of the six lines, with an example of each type, is given in this unit. These lines are used in combination with each other on all the blueprints in the Job Series. Problem material on the identification of lines is included in the Assignment Series.

The weights of lines are relative because they depend largely on the size of the drawing and the complexity of each member in a unit. For this reason, comparative weights of lines are used.

OBJECT LINES

The shape of an object is described on a drawing by heavy lines known as visible edge or "object lines". An object line (Fig. 4) is always drawn heavy and solid in order to emphasize clearly on the drawing what the outline or shape of the object is like (Fig. 5).

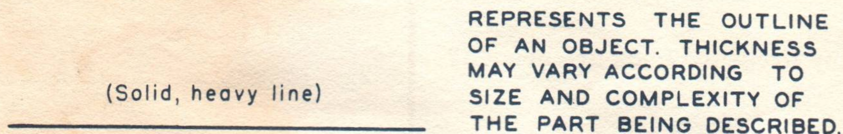


FIG. 4 OBJECT LINE

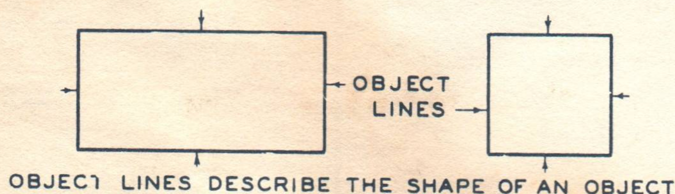
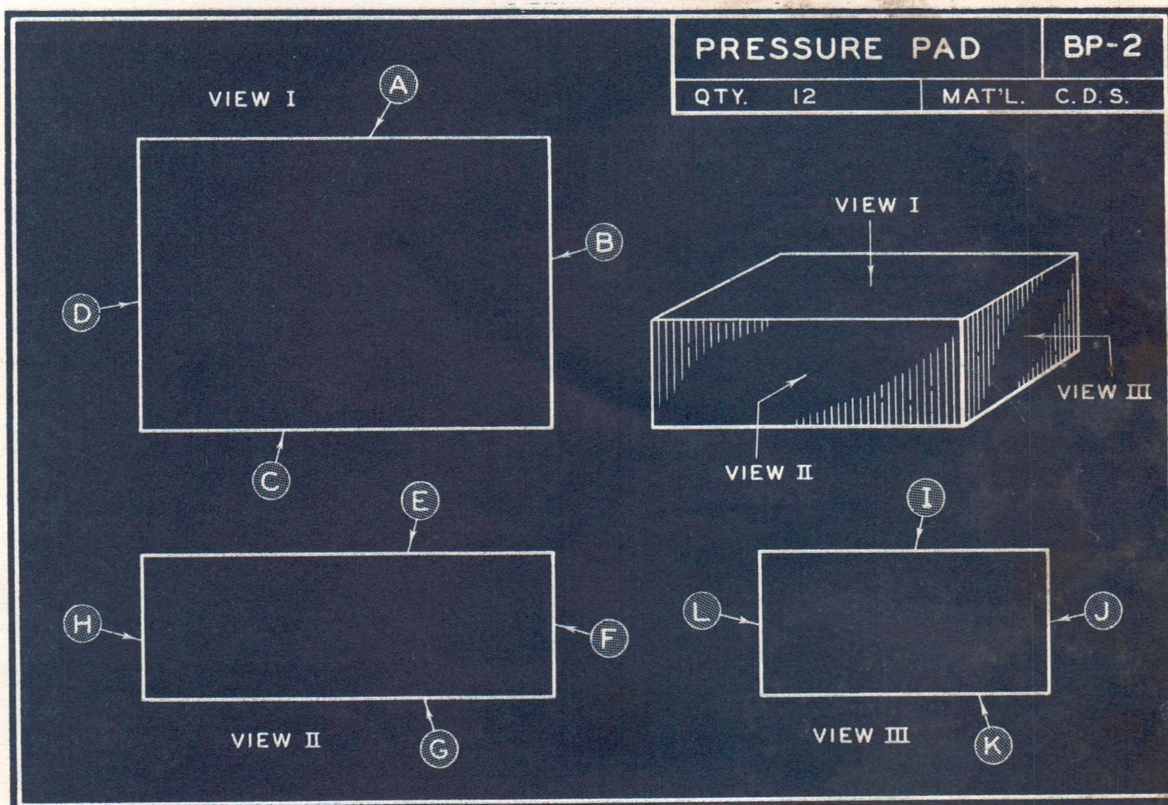


FIG. 5 APPLICATION OF THE OBJECT LINE



PRESSURE PAD (BP-2)

1. Give the name of the part.

2. What is the number of the blueprint?

3. How many Pressure Pads are needed?

4. What name is given to the heavy line which shows the shape of the part?

5. What lettered lines show the shape of the part in:

   a. View I

   b. View II

   c. View III

Assignment Unit 2	Student's Name ________

1. ____________

2. ____________

3. ____________

4. ____________

5. View I ____________

   View II ____________

   View III ____________

Unit 3 HIDDEN LINES - CENTER LINES

HIDDEN LINES

In order to be complete, a drawing must include lines which represent all the edges and intersections of surfaces in the object. Many of these lines are invisible to the observer because they are covered by other portions of the object. To show that a line is hidden, the draftsman usually uses a series of short dashes to denote "hidden lines" (Fig. 6). An example illustrating the use of hidden lines is given in Figure 7.

(Medium weight, short dashes)



REPRESENTS INVISIBLE EDGES AND SURFACES

FIG. 6 HIDDEN LINES

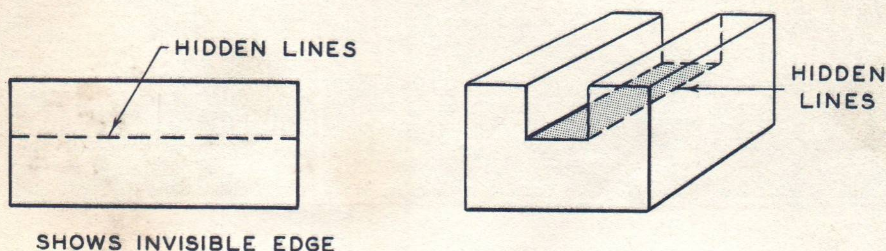


FIG. 7 APPLICATION OF HIDDEN LINES

CENTER LINES

A center line (Fig. 8) is drawn as a light broken line of long and short dashes, spaced alternately. Center lines may be used to indicate the center of a whole circle, a part of a circle, and also to show when an object is symmetrical about a line (Fig. 9).

(Light weight, long and short dashes)



INDICATES CENTERS OF CIRCLES, ARCS AND SYMMETRICAL OBJECTS

FIG. 8 CENTER LINES

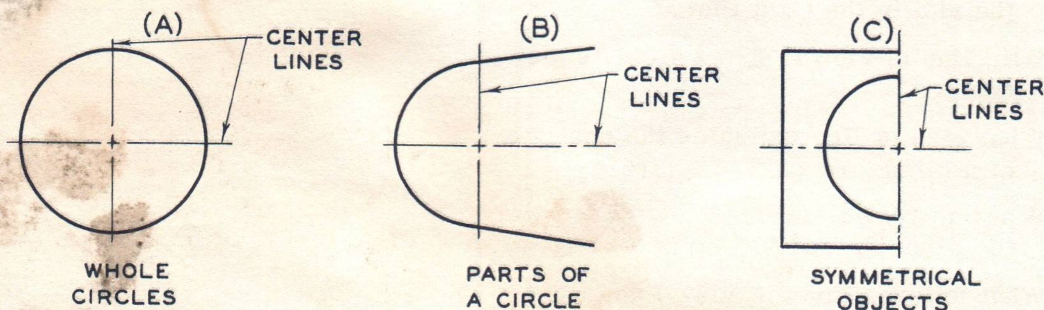
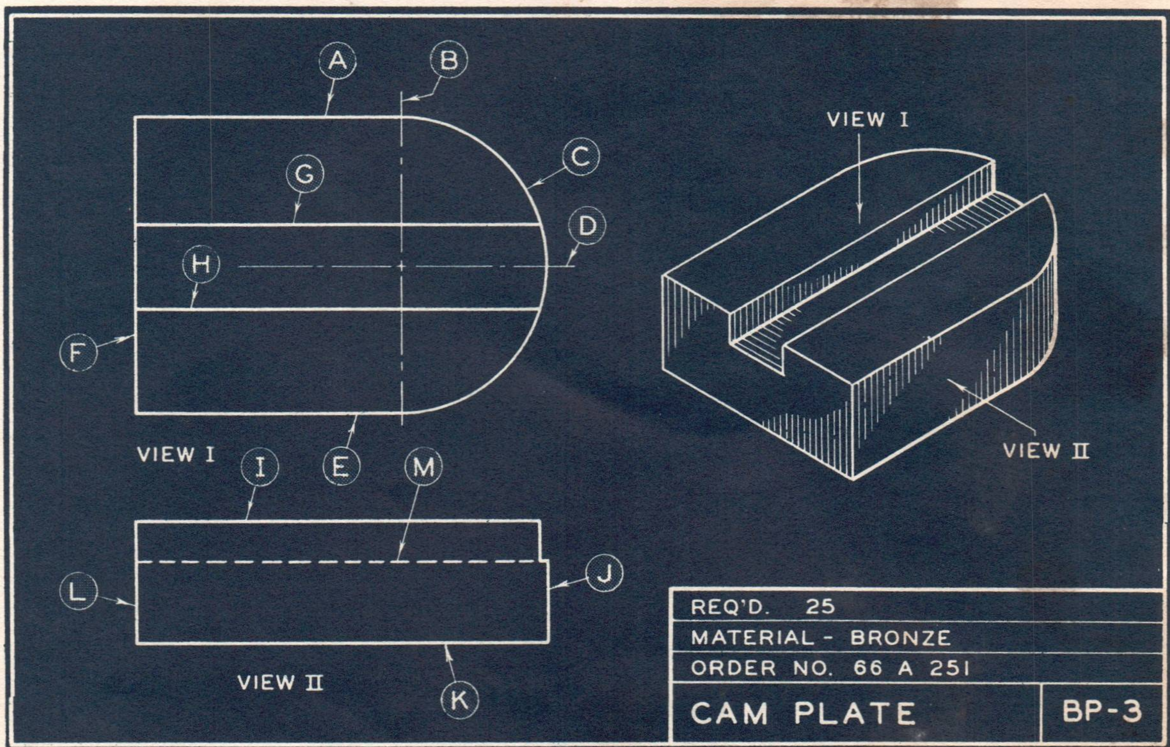


FIG. 9 APPLICATION OF CENTER LINES



CAM PLATE (BP-3)

1. How many Cam Plates are required?
2. Name the material for the parts.
3. What type line is used to describe the shape of the part?
4. Give the letters of all the lines which show the outside shape of the part.
5. Name the kind of line which represents an invisible edge.
6. What lettered lines in View I show the slot in the Cam Plate?
7. What line in View II shows an invisible surface?
8. What kind of line indicates the center of a circle, or part of a circle?
9. What lettered line in View I shows the circular end?
10. What lettered lines in View I are used to locate the center of the circular end?

Assignment Unit 3	Student's Name ________
1. ________	6. ________
2. ________	7. ________
3. ________	8. ________
4. ________	9. ________
________	10. ________
5. ________	________

Unit 4 EXTENSION LINES - DIMENSION LINES

EXTENSION LINES

Extension lines are used in dimensioning to show the size of an object. Extension lines (Fig. 10) are light, solid lines which extend away from an object at the exact places between which dimensions are to be placed.

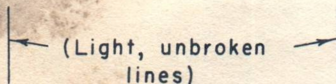


FIG. 10 EXTENSION LINES USED FOR DIMENSIONS

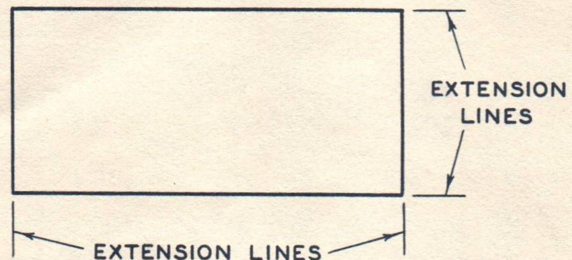


FIG. 11 APPLICATION OF EXTENSION LINES IN DIMENSIONING

A sixteenth-inch space is usually allowed between the object and the beginning of the extension line. The extension line (Fig. 11) usually projects 1/16" beyond a dimension line. Any additional length to the extension line is of no value in dimensioning.

DIMENSION LINES

Dimension lines (Fig. 12) are light, solid lines with arrowheads at their ends. The tips or points of these arrowheads indicate the exact distance referred to by a dimension.

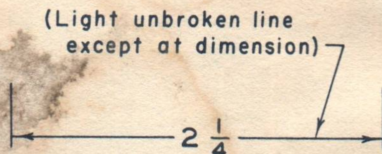


FIG. 12 DIMENSION LINE

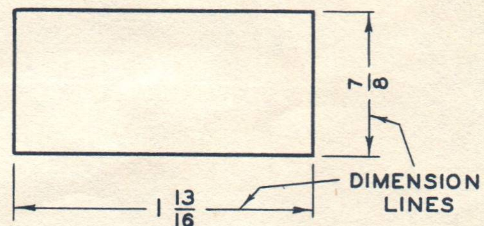
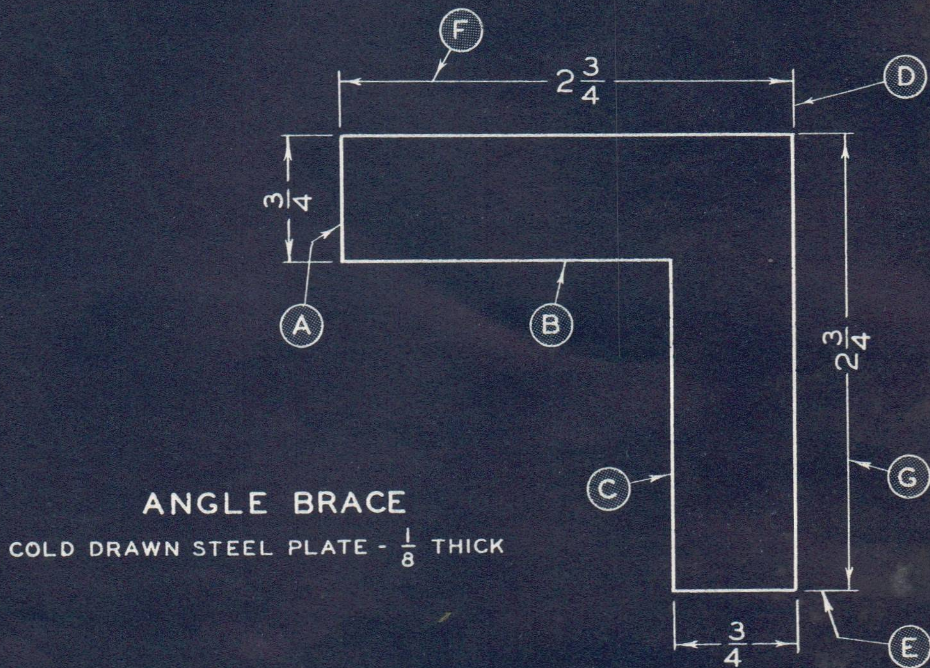
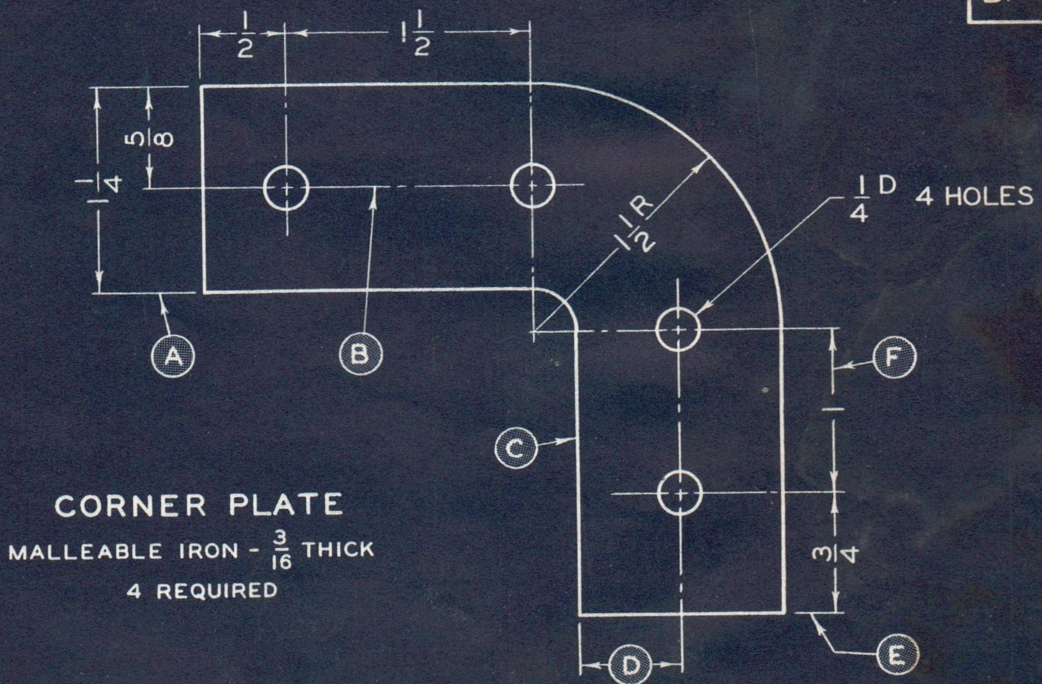


FIG. 13 APPLICATION OF DIMENSION LINES

The point or tip of the arrowhead touches the extension line. The size of the arrow is determined largely by the weight of the dimension line and the size of the drawing. The closed (⟵) and open (⟵) type arrowhead are the two shapes generally used.


BP-4A
F
2 3/4
D
3/4
A
B
2 3/4
G
C
ANGLE BRACE
COLD DRAWN STEEL PLATE - 1/8 THICK
3/4
E


BP-4B
1/2
1 1/2
5/8
1 1/4
1 1/2 R
1/4 D 4 HOLES
A
B
F
C
1
3/4
CORNER PLATE
MALLEABLE IRON - 3/16 THICK
4 REQUIRED
D
E

ANGLE BRACE (BP-4A)

1. What material is the Angle Brace made of?
2. What is the overall length of each side of the Brace?
3. What is the width of each leg of the Brace?
4. What is the thickness of the metal in the Brace?
5. What is the name given to the kind of line marked (A), (B) and (C)?
6. What kind of lines are (D) and (E)?
7. What kind of lines are (F) and (G)?
8. Why are object lines made heavier than extension and dimension lines?

Assignment Unit 4A	Student's Name ________
1. Colddrawn steel	5. ________
________	________
2. 2 3/4	6. ________
3. 3	7. ________
4. 1/8	________
8. ________	

CORNER PLATE (BP-4B)

1. What kind of line is (A)?
2. What kind of line is (B)?
3. What kind of line is (C)?
4. Determine the overall length of the Plate from left to right.
5. Determine the overall width of the Plate from top to bottom.
6. Give the center distance between the two upper holes.
7. Determine distance (D).
8. What kind of line is (E)?
9. What kind of line is (F)?
10. What radius forms the rounded corner of the Plate?
11. What material is the Plate made of?
12. How many Corner Plates are required?

Assignment Unit 4B	Student's Name ________
1. ________	7. ________
________	8. ________
2. ________	________
________	9. ________
3. ________	________
________	10. ________
4. ________	11. ________
5. ________	________
6. ________	12. ________

Unit 5 PROJECTION LINES - OTHER LINES - LINE COMBINATIONS

PROJECTION LINES

Ordinarily, projection lines are used by draftsmen and designers to establish the relationship of lines and surfaces in one view with corresponding points in other views. Projection lines do not appear on finished drawings except where a part is complicated and it becomes necessary to show how certain details on a drawing are obtained. Projection lines (Fig. 14) are fine unbroken lines projected from a point in one view to locate the same point in another view.

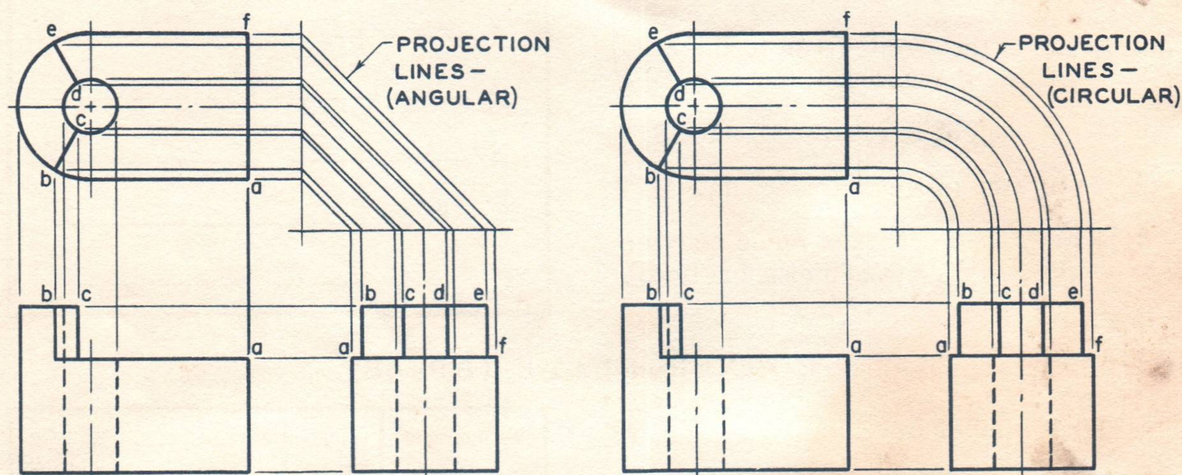
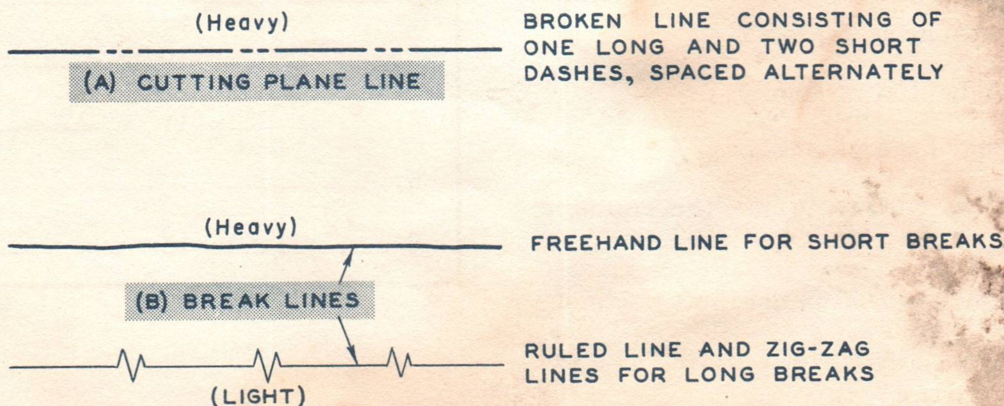


FIG. 14 APPLICATION OF PROJECTION LINES

OTHER LINES

The "alphabet" includes many other types of lines such as: the cutting plane line, break lines, lines to indicate adjacent parts and alternate positions and lines for repeated detail. The less frequently used lines described in Figure 15 are found in more advanced drawings and will be described in greater detail in relation to these drawings.



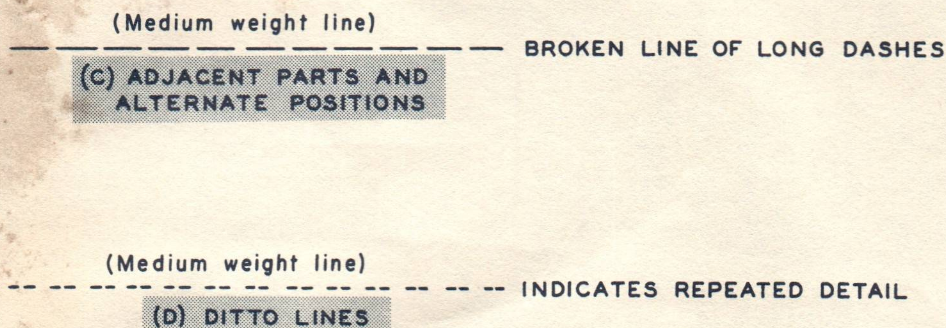


FIG. 15 SAMPLES OF OTHER LINES USED ON DRAWINGS

LINES USED IN COMBINATION

Most drawings consist of a series of object lines, hidden lines, center lines, extension lines and dimension lines used in combination with each other to fully describe a part or mechanism (Fig. 16).

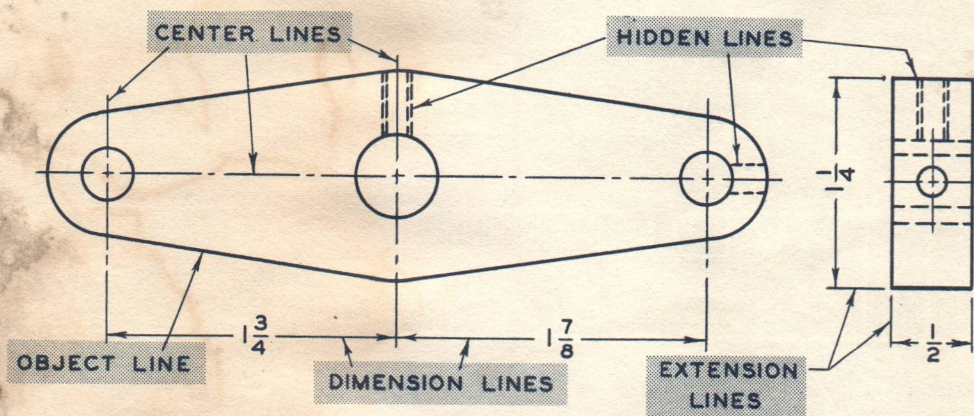
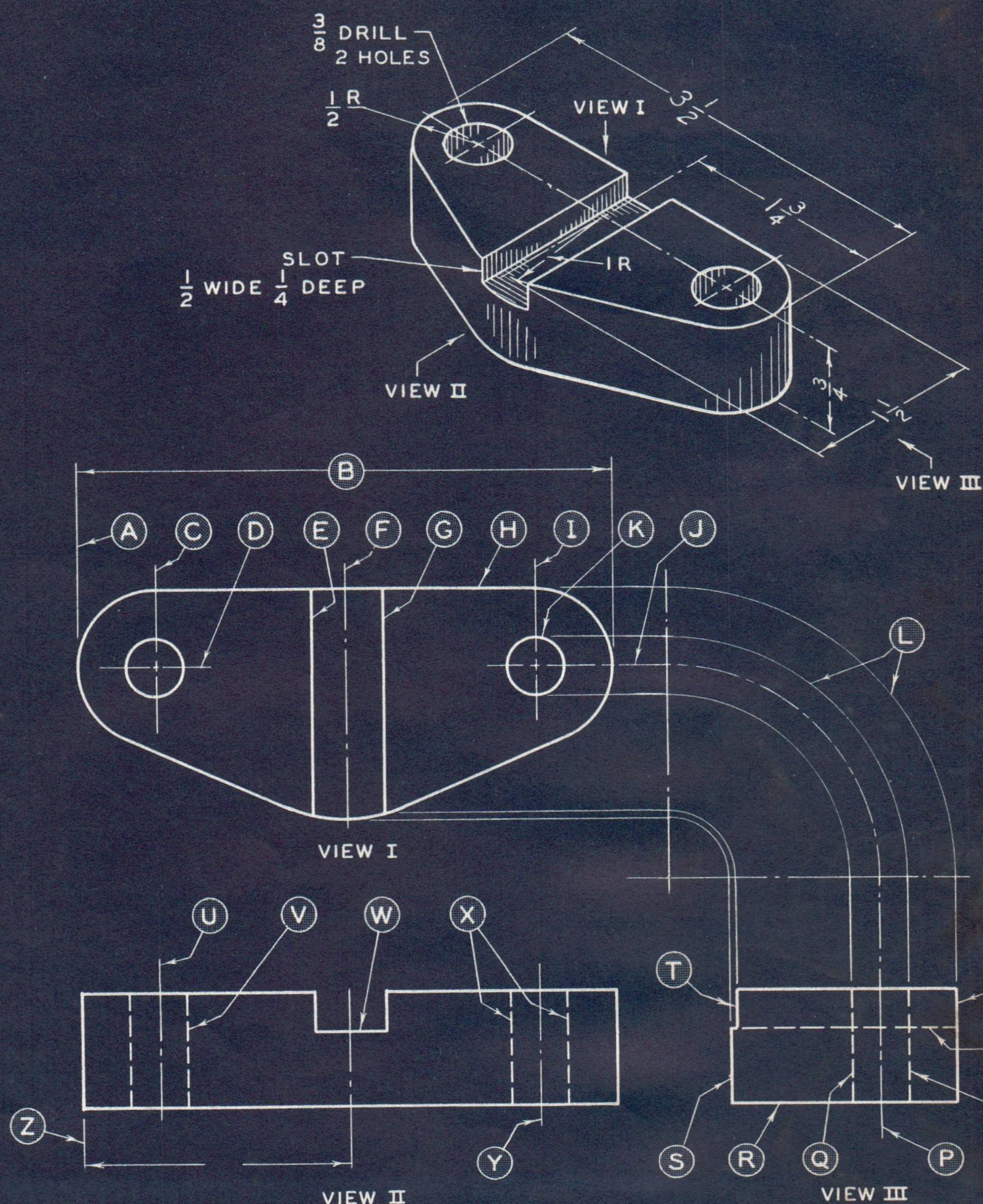


FIG. 16 LINES USED IN COMBINATION



MATERIAL: GRAY CAST IRON	
ORDER NO.	QUANTITY
2A 56-72	24
FEEDER PLATE	BP-5

FEEDER PLATE (BP-5)

1. What is the name of the part?
2. What is the blueprint number?
3. What is the Plate order number?
4. How many parts are to be made?
5. What material is the part made of?
6. Study the Feeder Plate blueprint.
   a. Locate and name each line from (A) to (Z) in the space provided for it in the table.
   b. Tell how each line from (A) to (L) is identified.

NOTE: Line (A) is filled in as a guide.

Assignment Unit 5	Student's Name __________

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________

LINE ON DRAWING	(A) NAME OF LINE	(B) HOW THE LINE IS IDENTIFIED
(A)	EXTENSION LINE	FINE, UNBROKEN LINE
(B)		
(C)		
(D)		
(E)		
(F)		
(G)		
(H)		
(I)		
(J)		
(K)		
(L)		

LINE ON DRAWING	(A) NAME OF LINE
(M)	
(N)	
(O)	
(P)	
(Q)	
(R)	
(S)	
(T)	

LINE ON DRAWING	(A) NAME OF LINE
(U)	
(V)	
(W)	
(X)	
(Y)	
(Z)	

Unit 6 THREE-VIEW DRAWINGS

Flat objects that have regular shapes and include only simple machining operations are often adequately described with notes on a one-view drawing. However, when the shape of the object changes, or portions are cut away and relieved, or complex machining or fabricating processes must be represented on the drawing, the one-view may not be sufficient to describe the part accurately.

The number and selection of views is governed by the shape or complexity of the object. No view should be drawn unless it adds to the ease with which a drawing can be read or furnishes other information needed to describe the part clearly.

Throughout this text as more complex drawings are to be interpreted, the basic principles underlying the use of all additional views which are needed to describe the true shape of the object will be covered at that time. Immediate application of these principles will then be made on typical industrial blueprints.

The combination of front, top, and right side views represents the three views most commonly used in drafting rooms to describe simple objects. The manner in which each view is obtained and the interpretation of each view is discussed in this section.

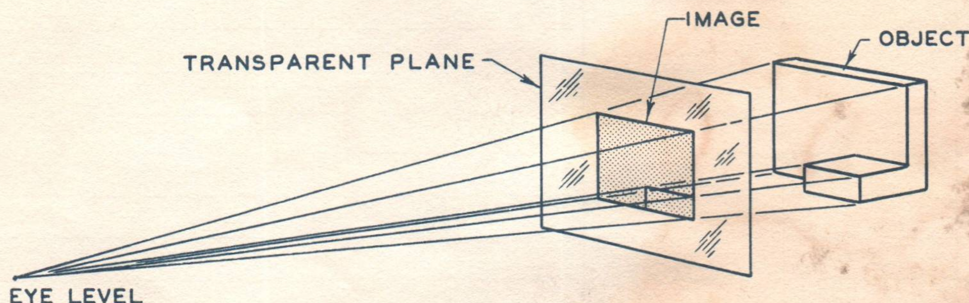


FIG. 17 PROJECTING IMAGE FOR FRONT VIEW (CONVERGING RAYS)

THE FRONT VIEW

Before an object is drawn, it is examined to determine which views will furnish the most information. The surface which is to be shown as the observer looks at it is called the Front View. To draw this view, the draftsman goes through an imaginary process of raising the object to eye level and turning it so that only one side can be seen. If an imaginary transparent plane is set parallel between the eye and the face of the object, the image projected on the plane will be the same as that formed in the eye of the observer (Fig. 17).

It will be noted from Fig. 17 that the rays converge as they approach the observer's eye. If, instead of converging, these rays were parallel as they left the object, they would form on the screen an image which would be equivalent to a Front View as shown in Fig. 18.

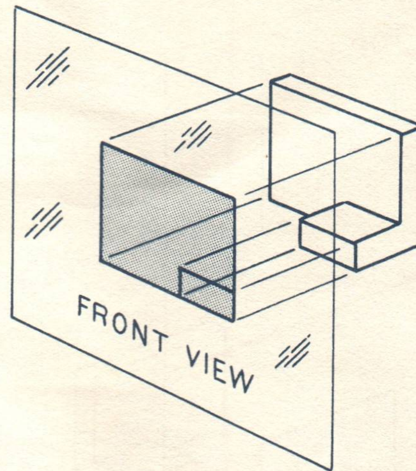


FIG. 18 FRONT VIEW OF OBJECT

THE TOP VIEW

In order to draw a Top View, the draftsman goes through a process similar to that required to obtain the Front View. But, instead of placing himself squarely in front of the object, he imagines himself to be looking down from a point immediately above it (Fig. 19).

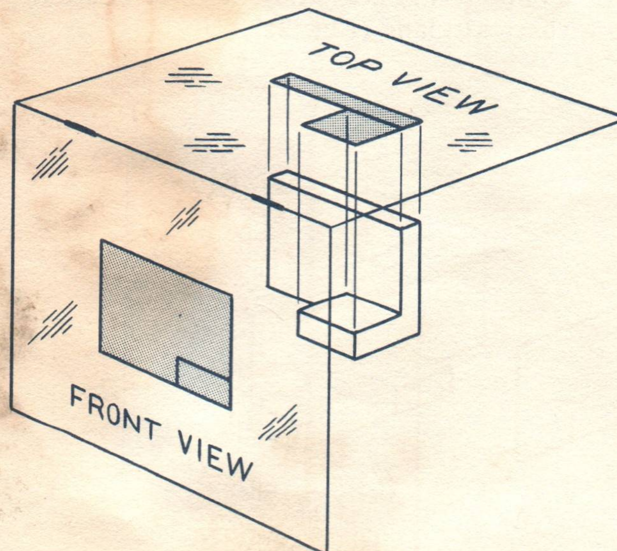


FIG. 19 PROJECTING IMAGE TO FORM TOP VIEW

When the horizontal plane on which the top view has been projected is rotated so that it is in a vertical plane, as shown in Figure 20, the front and top views are in their proper relationship. In other words, the top view is always placed immediately above and in line with the front view (Fig. 20).

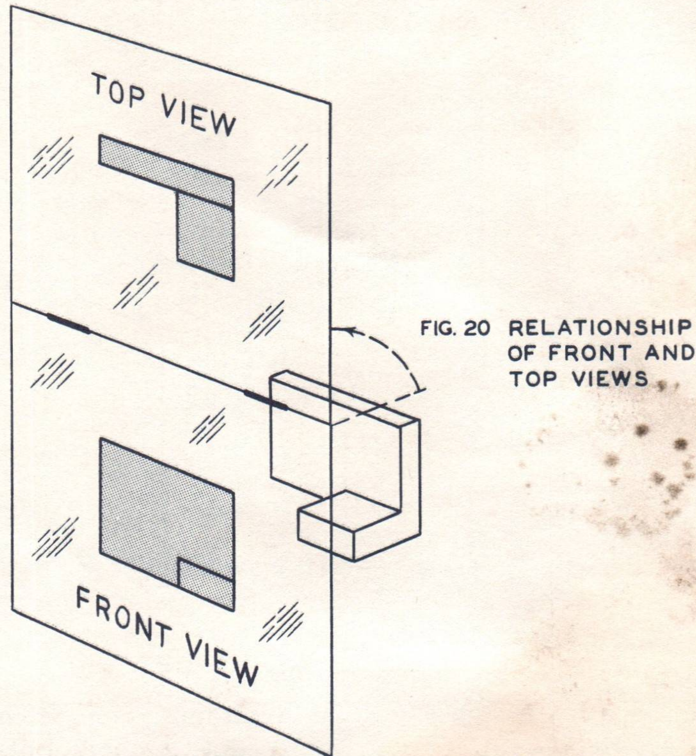


FIG. 20 RELATIONSHIP OF FRONT AND TOP VIEWS

A side view is drawn in much the same way that the other two views were obtained. The draftsman imagines he is viewing the object from the side that he wishes to draw and proceeds to draw the object as it would appear if parallel rays were projected upon a vertical plane (Fig. 21).

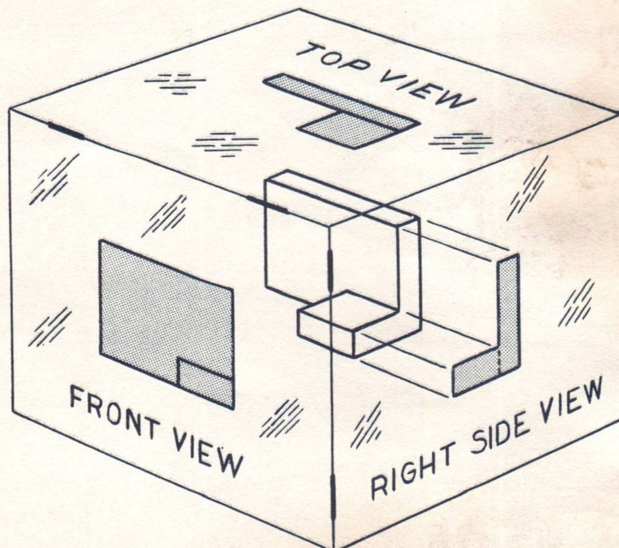


FIG. 21 PROJECTING IMAGE TO FORM RIGHT SIDE VIEW

FRONT, TOP AND RIGHT SIDE VIEWS

By swinging the top of the imaginary projection box to a vertical position and the right side forward, the top view is directly above the front view, and the side view is to the right of the front view and in line with it. The illustration given below in Figure 22 shows the front, top and right side views in the positions in which they would appear on a blueprint.

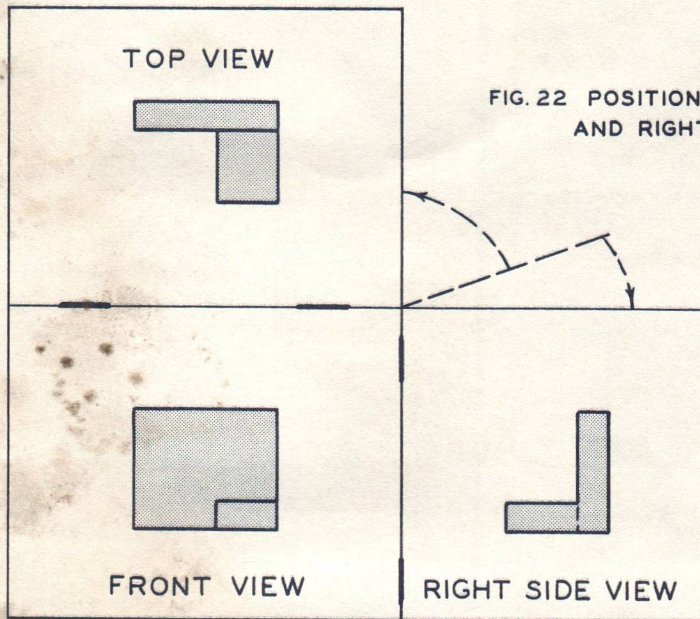


FIG. 22 POSITIONS OF FRONT, TOP AND RIGHT SIDE VIEWS

WORKING DRAWINGS

An actual drawing of the part would show only the top, front and right side views without the imaginary transparent planes (Fig. 23). These views show the exact shape and size of the object and the relationship of one view to another.

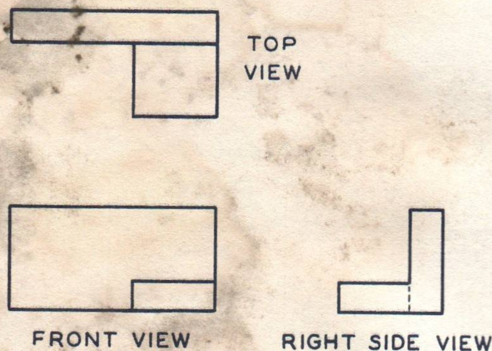


FIG. 23 VIEWS WITH TRANSPARENT PLANES REMOVED

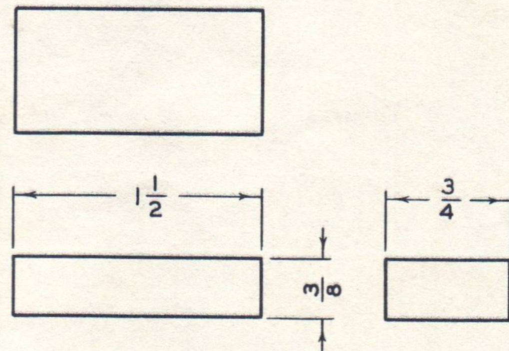
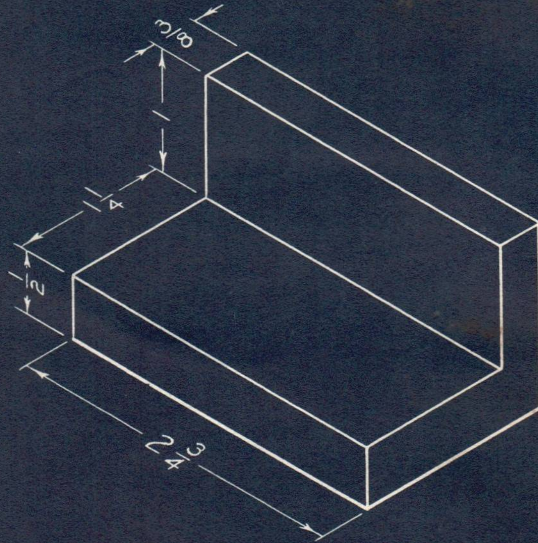
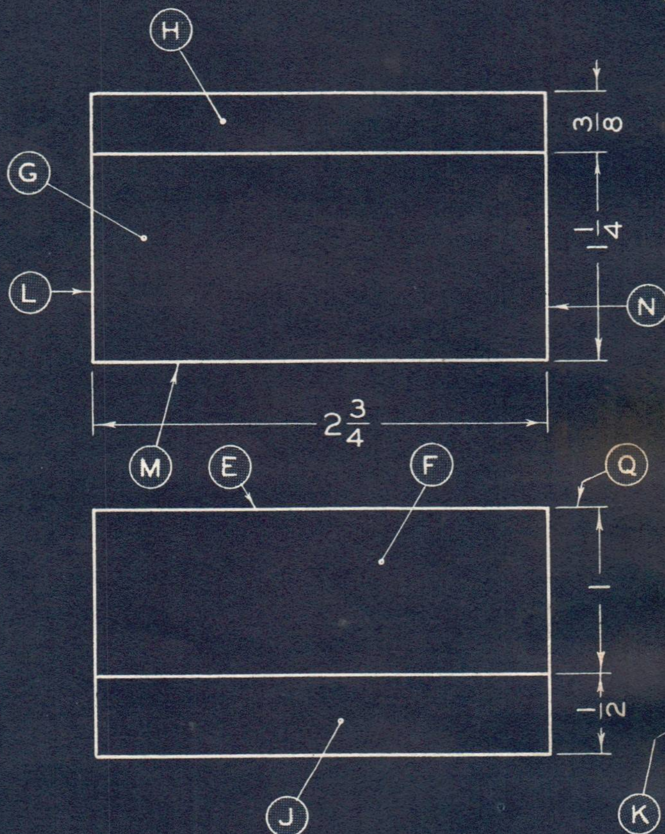


FIG. 24 EXAMPLE OF A WORKING DRAWING

A mechanical drawing, when made complete by the addition of dimensions and other necessary notes, is called a working drawing because it furnishes full information for constructing the object (Fig. 24).





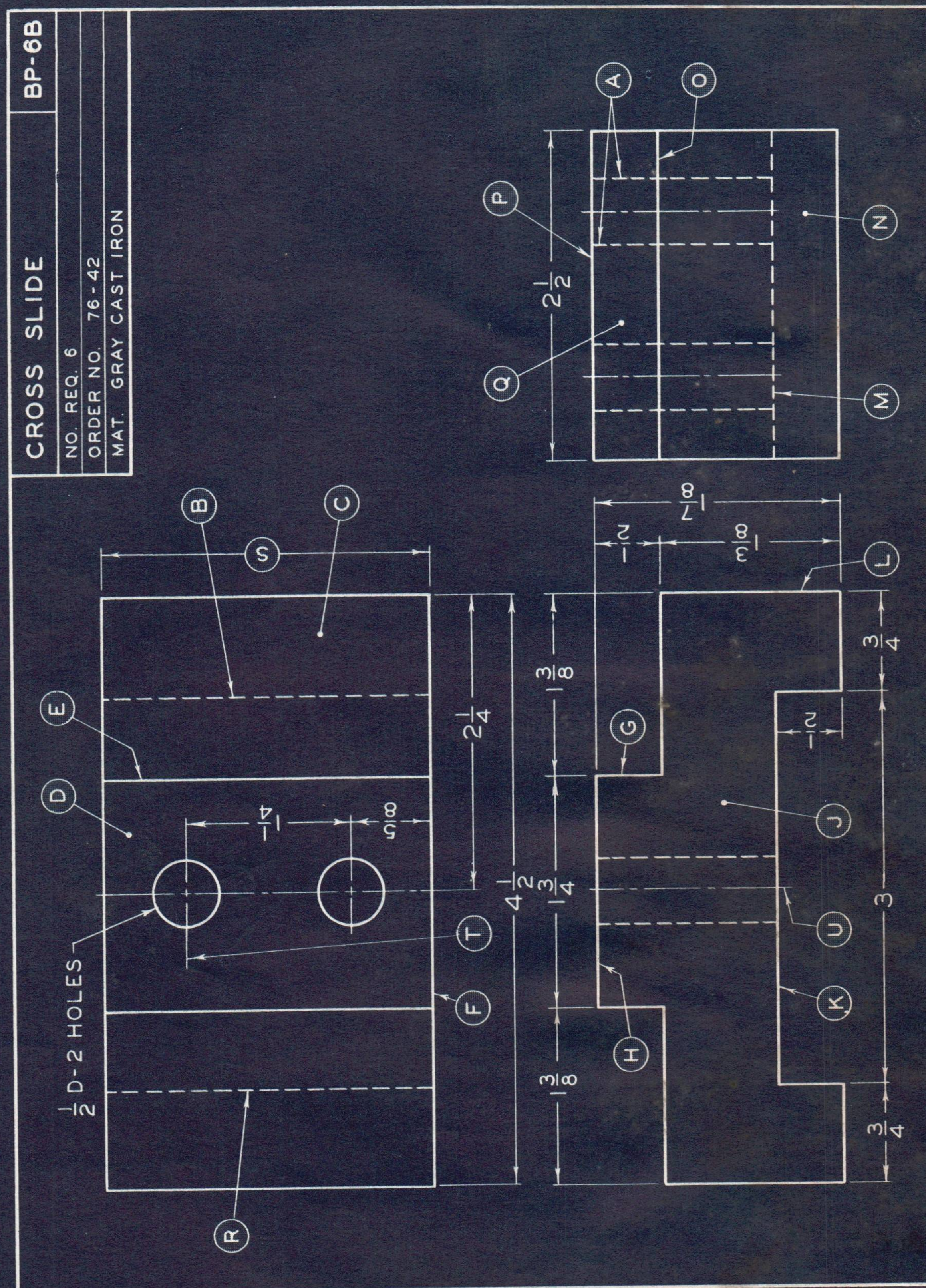
NO. REQ. 4	
ORDER NO. 4-57	
MAT. CAST IRON	
ANGLE BRACKET	BP-6A

ANGLE BRACKET (BP-6A)

1. How many Angle Brackets are required?
2. What material is the Angle Bracket made of?
3. State the order number of the Bracket.
4. What is the overall length?
5. What is the overall height?
6. What is the overall width?
7. Give dimension (A)?
8. Give dimension (B).
9. What surface in the top view does line (C) in the right side view represent?
10. Name the three views used to describe the shape and size of the part.
11. What surface in the top view does line (D) in the right side view represent?
12. What line in the right side view represents surface (F) in the front view?
13. What line in the right side view represents (J) in the front view?
14. What line in the top view represents surface (O) in the right side view?
15. What line in the front view represents surface (H) in the top view?
16. What line in the right side view represents surface (H) in the top view?
17. What kind of lines are (E) (L) (C) (D) and (K)?
18. What kind of lines are (A) and (B)?
19. Give the encircled letter that denotes an extension line.
20. What encircled letter in the front view denotes an object line?

Assignment Unit 6A	Student's Name

1. 4
2. Cast iron
3. 4-57
4. 2 3/4
5. 1 1/2
6. 1 5/8
7. 1 1/4
8. 3/8
9. H
10. front top R. side
11. G
12. P
13. ~~Q~~ K
14. ~~X~~ N
15. E
16. C
17. object lines
18. dimension lines
19. Q B
20. E


CROSS SLIDE
BP-6B
NO. REQ. 6
ORDER NO. 76-42
MAT. GRAY CAST IRON
1/2 D-2 HOLES

CROSS SLIDE (BP-6B)

1. What material is used for the Cross Slide?
2. How many pieces are required?
3. What is the overall length of the Cross Slide?
4. What is the order number?
5. What is the overall height?
6. What are the lines marked (A) and (B) called?
7. What do the lines marked (A) represent?
8. What two lines in the top view represent the slot shown in the front view?
9. What line in the right side view represents the slot shown in the front view?
10. What line in the front view represents surface (Q) in the right side view?
11. What line in the front view represents surface (D) in the top view?
12. What line in the top view represents surface (J) in the front view?
13. What line in the side view represents surface (D) in the top view?
14. What is the diameter of the holes?
15. What is the center to center dimension of the holes?
16. How far is the center of the first hole from the front surface of the slide?
17. Are the holes drilled all the way through the slide?
18. What is the width of the slot shown in the front view?
19. What is the depth of the slot?
20. Determine dimension (S).
21. What is the width of the projection at the top of the slide?
22. How high is the projection?
23. What kind of line is (M)?
24. What kind of line is used at (O) and (P)?

Assignment Unit 6B	Student's Name	
1. [illegible]	8. RB	17. Yes
2. 6	9. M	18. 3
3. 4 1/32	10. G	19. 1/2
4. 76-42	11. H	20. 2 1/2
5. 1 7/8	12. F	21. 1 3/4
6. hidden lines	13. P	22. 1/2
	14. 1/2	23. hidden line
7. a 1/2 hole	15. 1 1/4	24. object lines
	16. 5/8	

Unit 7 ARRANGEMENT OF VIEWS

The main purpose of a drawing is to impart sufficient information to the craftsman so he can build, inspect or assemble a part or mechanism according to the specifications of a designer. Since the selection and arrangement of views depends upon how simple or complex a part is, only those views should be drawn which help in the interpretation of the drawing.

The average drawing which includes a front, top and side view is known as a three-view drawing. However, the designation of the views is not as important as the fact that a combination of views gives all the details of construction in the most understandable way.

Usually, the draftsman selects as a front view of the object that view which best describes the general shape of the part. This front view may have no relationship with the actual front position of the part as it fits into a mechanism.

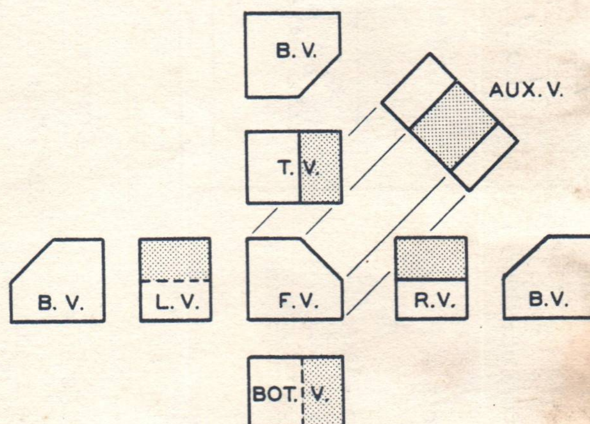


FIG. 25
IDENTIFICATION OF VIEWS

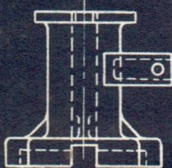
The names and positions of the different views that might be used to describe an object are illustrated in Figure 25. Note that the back view may be located in any one of three places. The views which are easiest to read and, at the same time, furnish all the required information should be the ones selected.

The name and abbreviation for each view is identified throughout this text as follows:

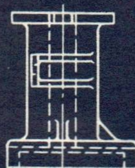
NAME OF VIEW	ABBREVIATION
Front View	(F.V.)
Right Side View	(R.V.)
Left Side View	(L.V.)
Bottom View	(Bot. V.)
Back or Rear View	(B.V.)
Auxiliary View	(Aux. V.)
Top View	(T.V.)

NAME THE VIEWS IN THE SPACES PROVIDED IN FIGURES 26, 27 AND 28	Assignment Unit 7	Student's Name

F.V.



R.V

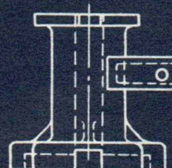




Bot. V

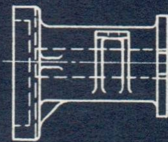
FIG. 26

F V





Bot.V.

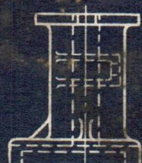


R.V. V.

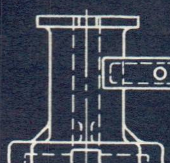
FIG. 27

T V

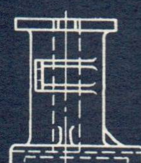




L V



F V



R V

FIG. 28

Unit 8 TWO-VIEW DRAWINGS

Cylindrical parts, such as sleeves, shafts, rods and studs and simple symmetrical flat objects, require only two views to give the full details of construction (Fig. 29). The two views usually include the front view used in combination with either a right or left side view, or a top or bottom view.

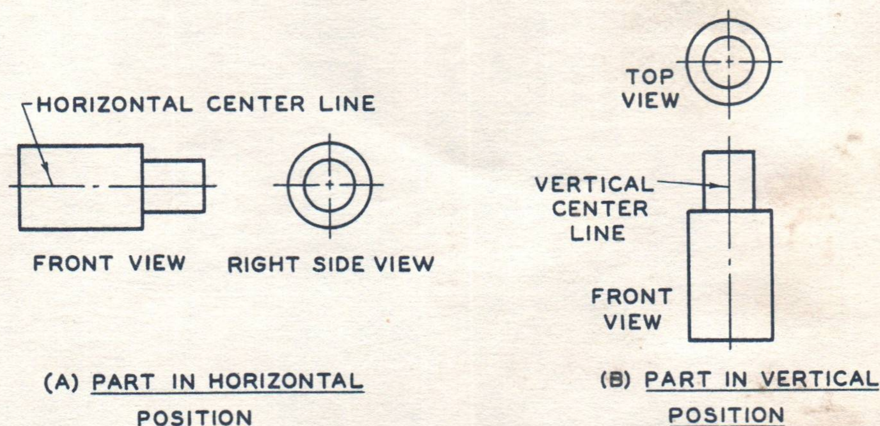
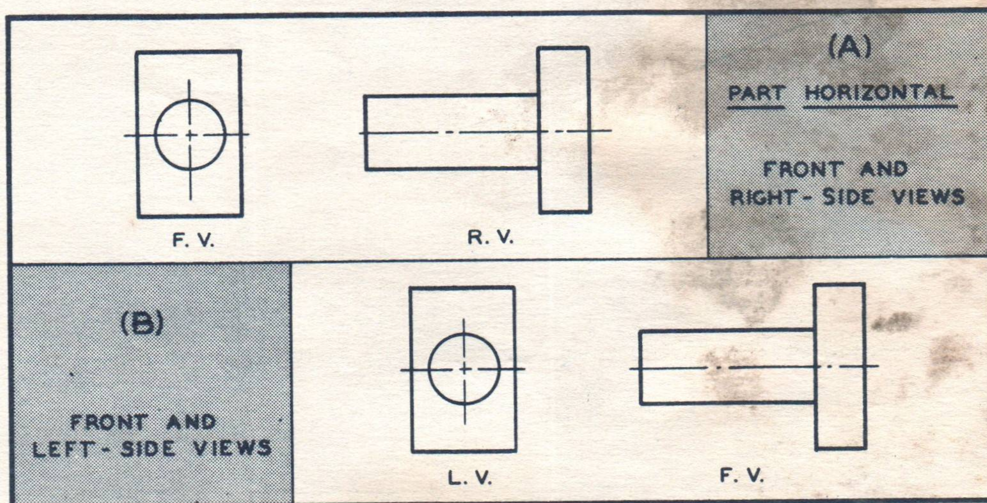


FIG. 29 EXAMPLES OF TWO-VIEW DRAWINGS OF A PLUG

In the front view, the center line runs through the axis of the part as either a horizontal center line, or if the plug is in a vertical position, the vertical axis of the part.

The second view of the two-view drawing contains a horizontal and a vertical center line intersecting at the center of the circles which go to make up this view.

The selection of views to use for a two-view drawing rests largely with the draftsman or designer. Some of the combinations of views commonly used in industrial plants are shown in Figure 30.



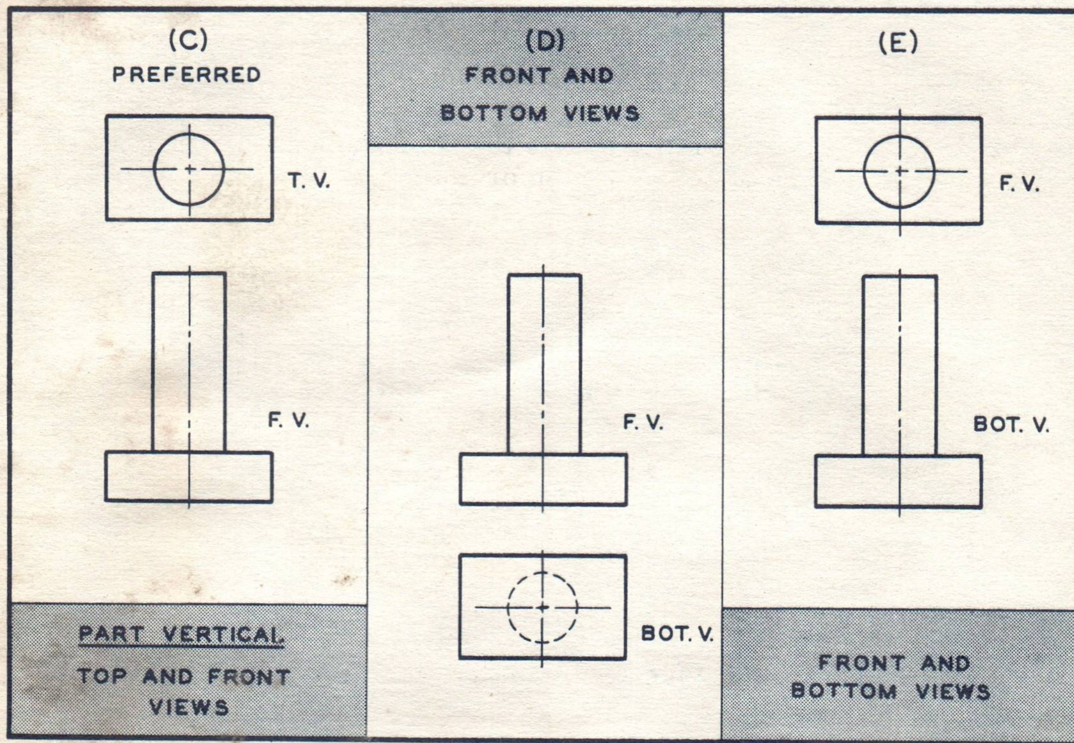


FIG. 30 COMBINATIONS OF TWO-VIEW DRAWINGS OF A PIN

Note at (A), (B), (D) and (E) that different names are used to identify the same views. The name of each view depends on how the draftsman views the object to get the front view.

REPRESENTING INVISIBLE CIRCLES

A hidden detail may be straight, curved or cylindrical. However, in every case it is represented by a hidden edge or invisible edge line regardless of the number or position of views (Fig. 31).

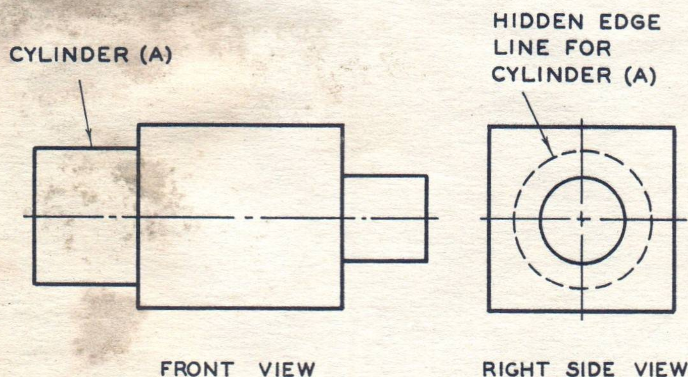
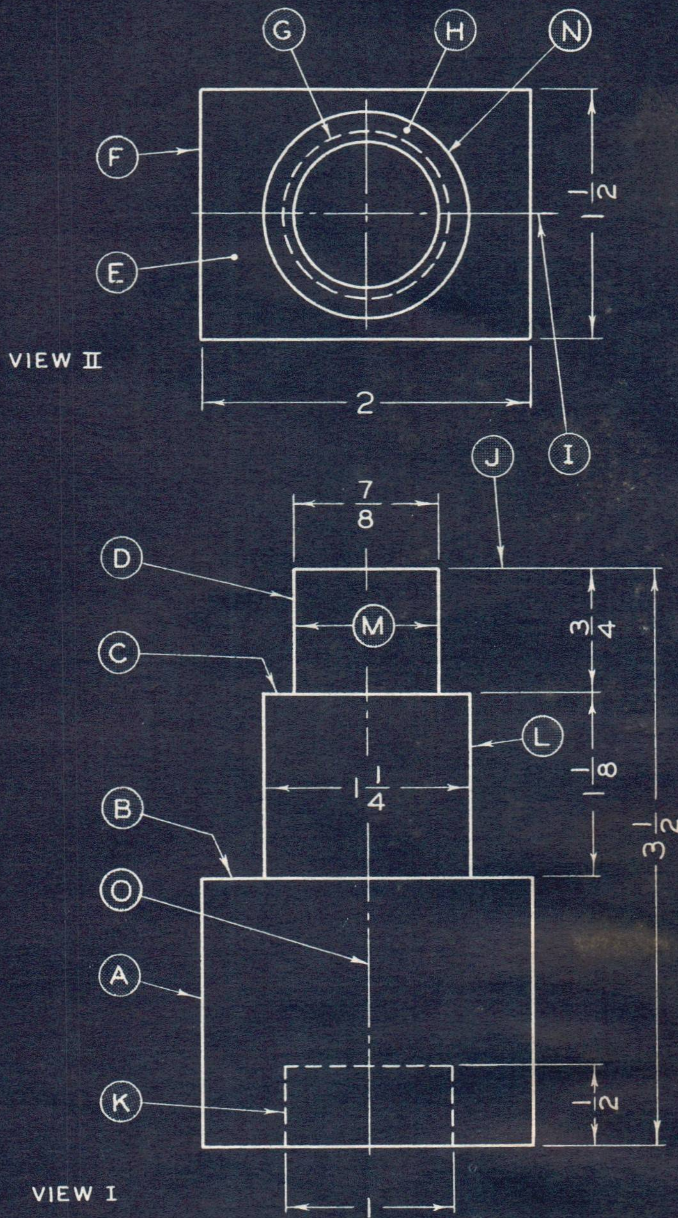


FIG. 31 USE OF INVISIBLE EDGE LINES

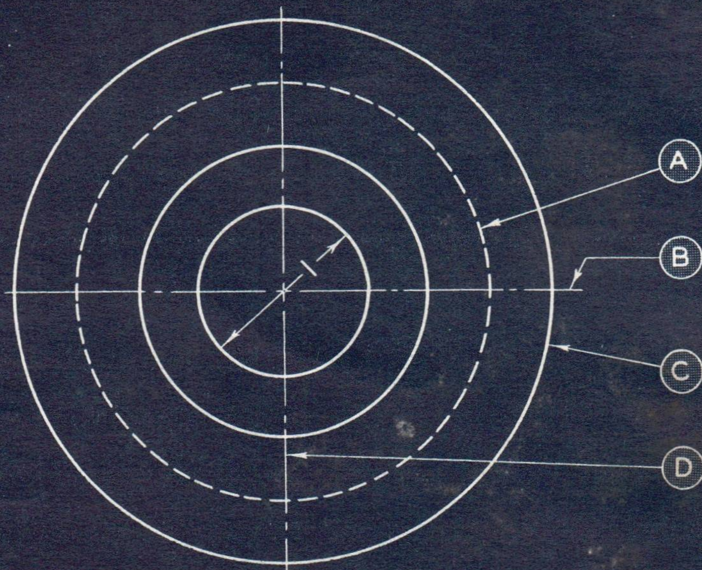


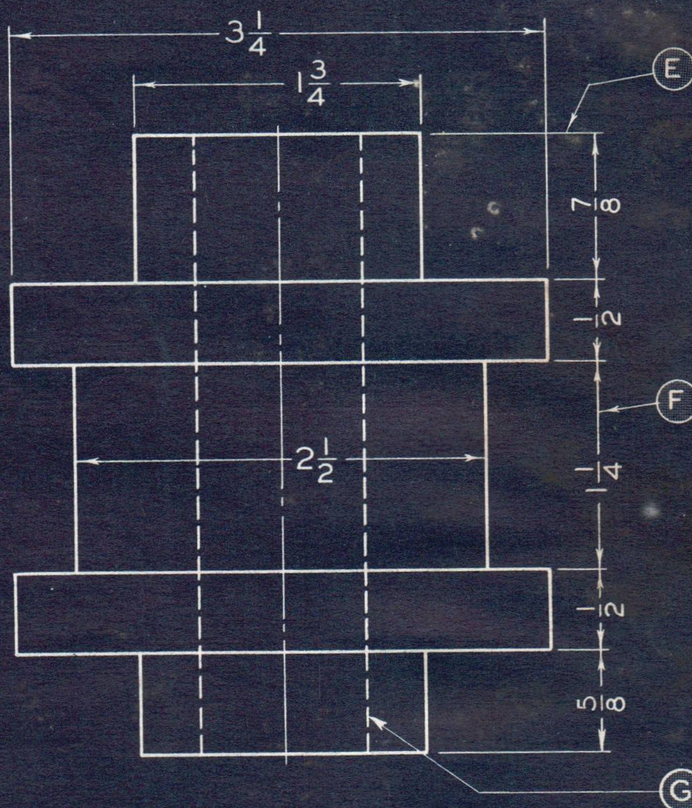
NO. REQ. 32	
ORDER NO. 76 - 32 - 05	
MATERIAL COLD DRAWN STEEL	
END SHAFT	BP-8A

END SHAFT (BP-8A)

1. Name the two views.
2. What line in View II represents surface (A) ?
3. What lettered surface in View II represents surface (B) ?
4. What circle in View II represents the 1" hole?
5. What line in View I represents surface (H) ?
6. Name line (I) .
7. What kind of line is (D) ?
8. Name line (J) .
9. What kind of line is (K) ?
10. What circle in the top view represents diameter (L) ?
11. What letters in View I represent object lines?
12. What letters in Views I and II represent center lines?
13. Give the diameter of (L) .
14. What is the smallest diameter of the shaft?
15. Determine the length of the 1 1/4" diameter portion.
16. What is the length of the rectangular part of the shaft?
17. Give the dimensions of the rectangular part.
18. Give the overall height of the shaft.
19. What is the order number?
20. State the material from which the shafts are to be machined.

Assignment Unit 8A	Student's Name _______
1.	front V. top V.
2.	F
3.	E
4.	G
5.	C
6.	center line
7.	object line
8.	extension
9.	hidden line
10.	N
11.	A B C D L M
12.	I O
13.	1 1/4
14.	7/8
15.	1 1/4
16.	~~2 1/4~~ 1 5/8
17.	2 × 1 1/2 × 1 5/8
18.	3 1/2
19.	76-32-05
20.	Cold drawn steel





NO. REQ. 12	
ORDER NO. 45-21	
MAT. C.D.S COLD DRAWN STEEL (SAE 1020)	
FLANGED SLEEVE	BP-8B

FLANGED SLEEVE (BP-8B)

1. What is the name of the part?
2. What is the order number?
3. How many pieces are required?
4. What material is used?
5. Name the two views which are used to represent the Flanged Sleeve.
6. Name the kind of line indicated by each of the following encircled letters.

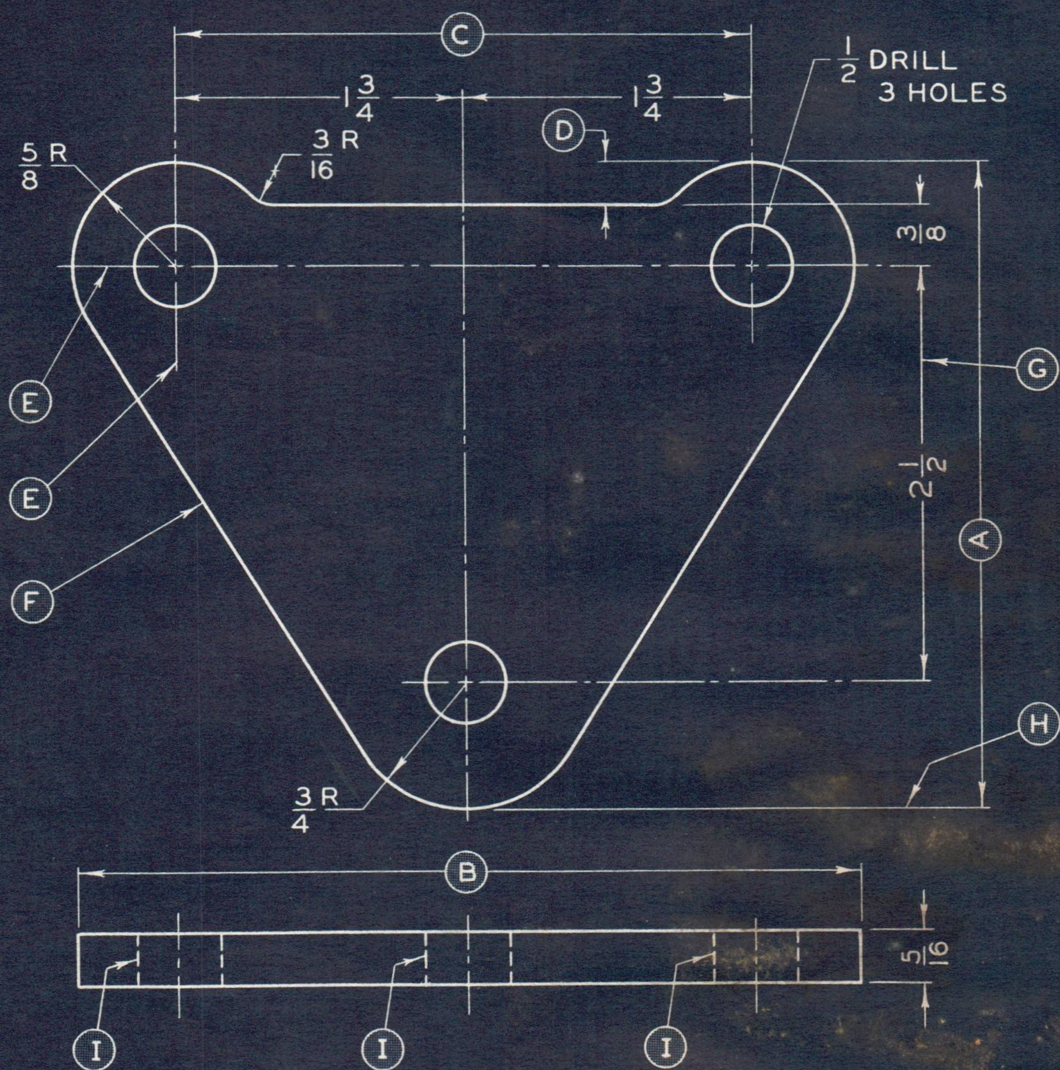
   (A) (E)
   (B) (F)
   (C) (G)
   (D)

7. What is the outside diameter of both flanges?
8. What is the thickness of each flange?
9. What is the diameter of the center hole?
10. Does the hole go all the way through the center?
11. What is the diameter of the hidden circle?
12. Determine the total or overall length of the Flanged Sleeve.

Assignment Unit 8B	Student's Name ________

1. flanged sleeve 7. 3 1/4
2. 45-21 8. 1/2
3. 12 9. 1
4. Cold drawn steel SAE 1020 10. Yes
5. Front V. top V. 11. 2 1/2
12. 3 3/4

6. (A) hidden line
(B) center line
(C) object line
(D) center line
(E) extension line
(F) dimension line
(G) hidden line



NO. REQ. 2	
ORDER NO. 4-76	
MAT'L. BRASS CASTING	
COVER PLATE	BP-8C

COVER PLATE (BP-8C)

1. What material is the part made of?
2. Name the two views used to describe the part.
3. Identify the kind of line indicated by each of the following encircled letters.

   (E) (H)
   (F) (I)
   (G)

4. What is the overall width (A)?
5. What is the overall length (B)?
6. How many holes have to be drilled?
7. What is the thickness of the plate?
8. What is the diameter of the holes?
9. What is the center distance between the center line of the two upper holes and the center line of the Plate?
10. Give the center distance (C) of the two upper holes?
11. What is the radius that forms the two upper rounds of the Plate?
12. What radius forms the lower part of the Plate?
13. What kind of line is drawn through the center of the Plate?
14. Determine distance (D).
15. How much stock is left between the edge of one of the upper holes and the outside of the piece?

Assignment Unit 8C	Student's Name ________

1. Brass
2. ~~top~~ ~~botom~~ front
3. (E) center line
   (F) object line
   (G) dimension line
   (H) extension line
   (I) hidden line
4. 3 1/8
5. 4 3/4
6. 3
7. 5/16
8. 1/2
9. 1 3/4
10. 3 1/2
11. 5/8
12. 1/4
13. center line
14. 1/4
15. 3/8

Unit 9 ONE-VIEW DRAWINGS

Many parts are uniform in shape and require only one view to describe them adequately. This is particularly true of cylindrical work where a one-view drawing saves time and simplifies the reading of a blueprint.

When a one-view drawing of a cylinder is used, the dimensions showing the diameter must be followed by the letter "D" as illustrated in Figure 32. This abbreviation of "D" for diameter and the use of a center line indicates that the part is cylindrical.

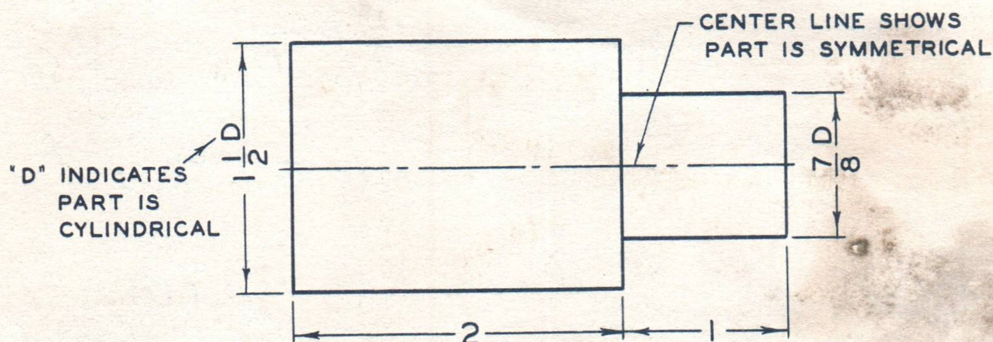


FIG.32 ONE-VIEW DRAWING OF A CYLINDRICAL SHAFT

The one-view drawing is also used extensively on flat parts where, by the use of simple notes which supplement the dimensions on the diagram, the one view furnishes all the necessary information for accurately describing the part (Fig. 33).

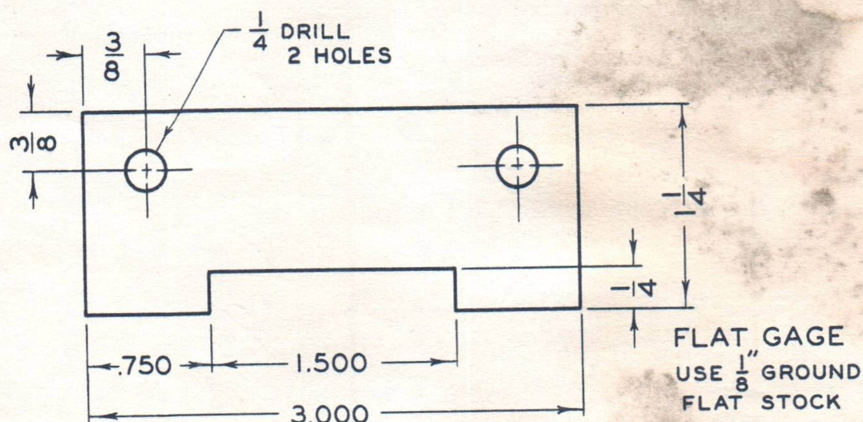
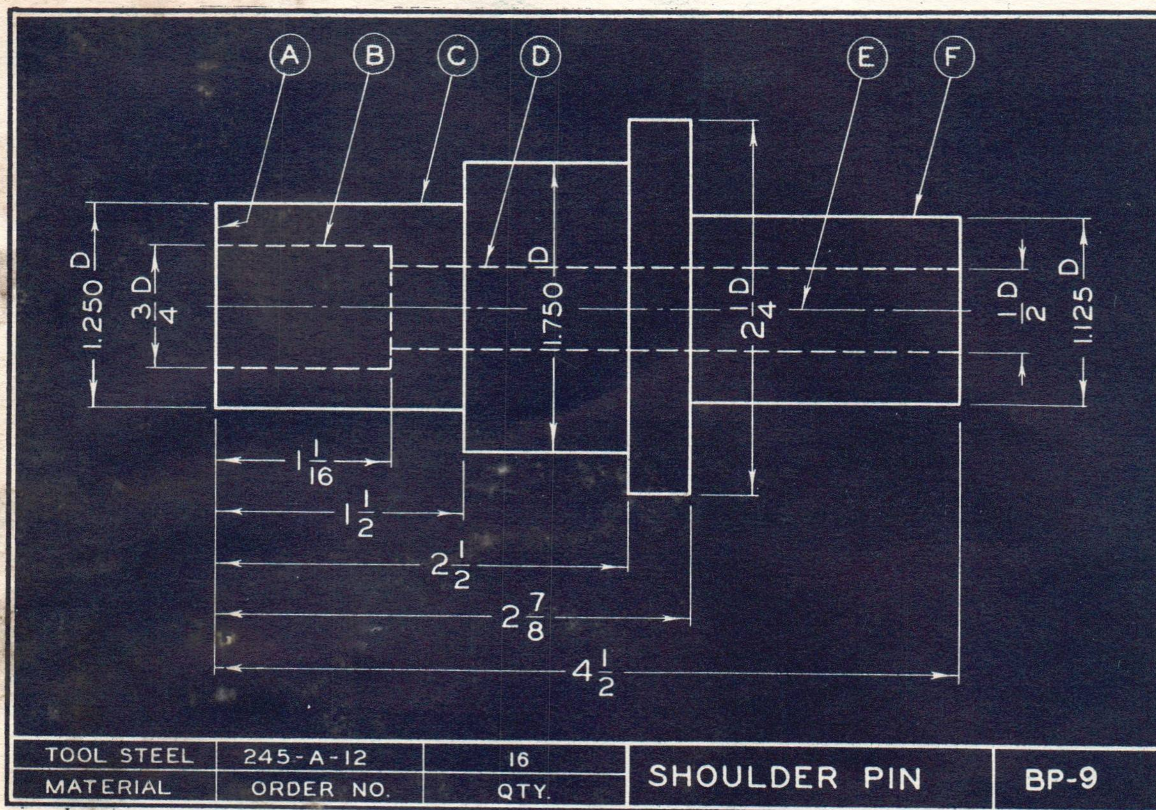


FIG. 33 ONE-VIEW DRAWING OF A FLAT PART



SHOULDER PIN (BP-9)

1. Name the view represented on BP-9.
2. What is the shape of the Shoulder Pin?
3. How many outside diameters are shown?
4. What is the largest diameter?
5. What diameter is the smallest hole?
6. What is the overall length?
7. How deep is the 3/4" hole?
8. How wide is the 1.750" D portion?
9. What letters represent object lines?
10. What kinds of lines are (B) and (D)?
11. What letter represents the center line?
12. What does the center line indicate about the holes and outside diameters?
13. Give the width of the 2 1/4" D portion.
14. State the order number of the part.
15. Give the material in the pins.

Assignment Unit 9	Student's Name ________
1. front V	9. A C F
2. cylindrical	10. hidden lines
3. ~~3~~ 4	11. E
4. 2 1/4 D	12. holes are centered
5. 1/2 D	13. 3/8
6. 4 1/2	14. 245-A-12
7. 1 1/16	15. tool steel
8. 1	

Unit 10 AUXILIARY VIEWS

As long as all the surfaces of an object are parallel or at right angles to one another, they may be represented in one or more regular views (Fig. 34).

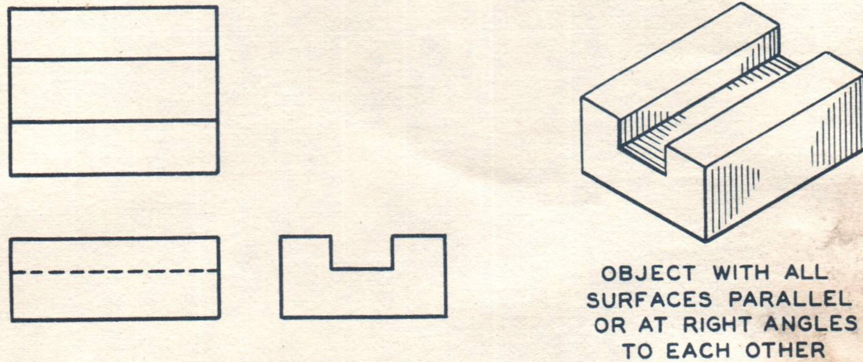


FIG. 34 REPRESENTATION OF OBJECT USING REGULAR VIEWS

The surfaces of such objects can be projected in their true size and shape on either a horizontal or vertical plane, or any combination of these planes.

Where one or more surfaces of an object slant and are inclined away from either a horizontal or vertical plane, the regular views will not show the true shape of the inclined surface (Fig. 35). If the true shape must be shown, the draftsman, in addition to drawing the regular views, uses what is called an "auxiliary view" to accurately represent the angular surface.

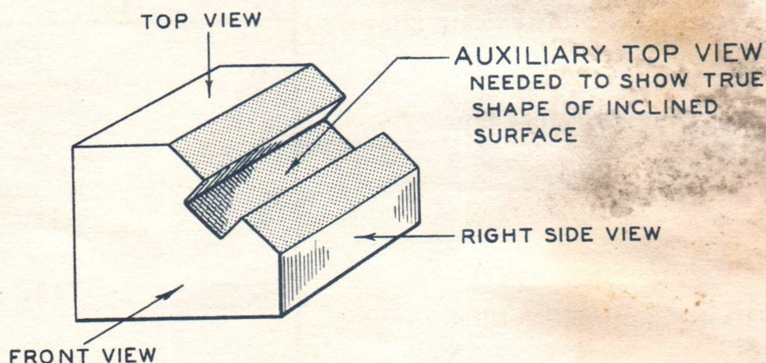


FIG. 35 OBJECT REQUIRING USE OF AUXILIARY VIEW

APPLICATION OF AUXILIARY VIEWS

Auxiliary views may be full views or partial views as shown in Figure 36 where only the inclined surface and other required details are included. In an auxiliary view the inclined surface is projected on an imaginary plane which is parallel to it. Rounded surfaces and circular holes which are distorted and appear as ellipses in the regular views, appear in their true shape and size in an auxiliary view.

Auxiliary views are named according to the position from which the inclined face is seen. They may be auxiliary front, top, bottom, left or right side views. On drawings of complex parts involving compound angles, one auxiliary view is sometimes developed from another. The first auxiliary view is called "primary" and those developed from it "secondary" auxiliary views. For the present, attention is focused on primary auxiliary views.

SUMMARY

Auxiliary views are usually partial views which show only the inclined surface. In Figure 36 the true size and shape of surface (A) is shown in the auxiliary view of the angular surface.

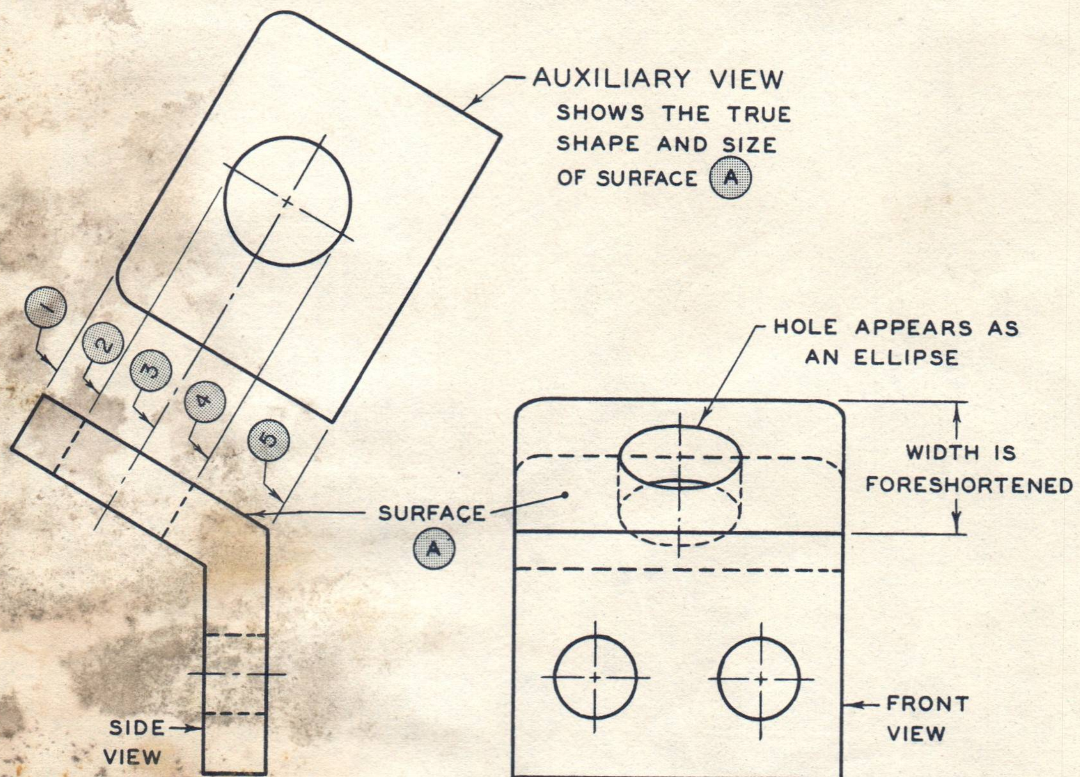
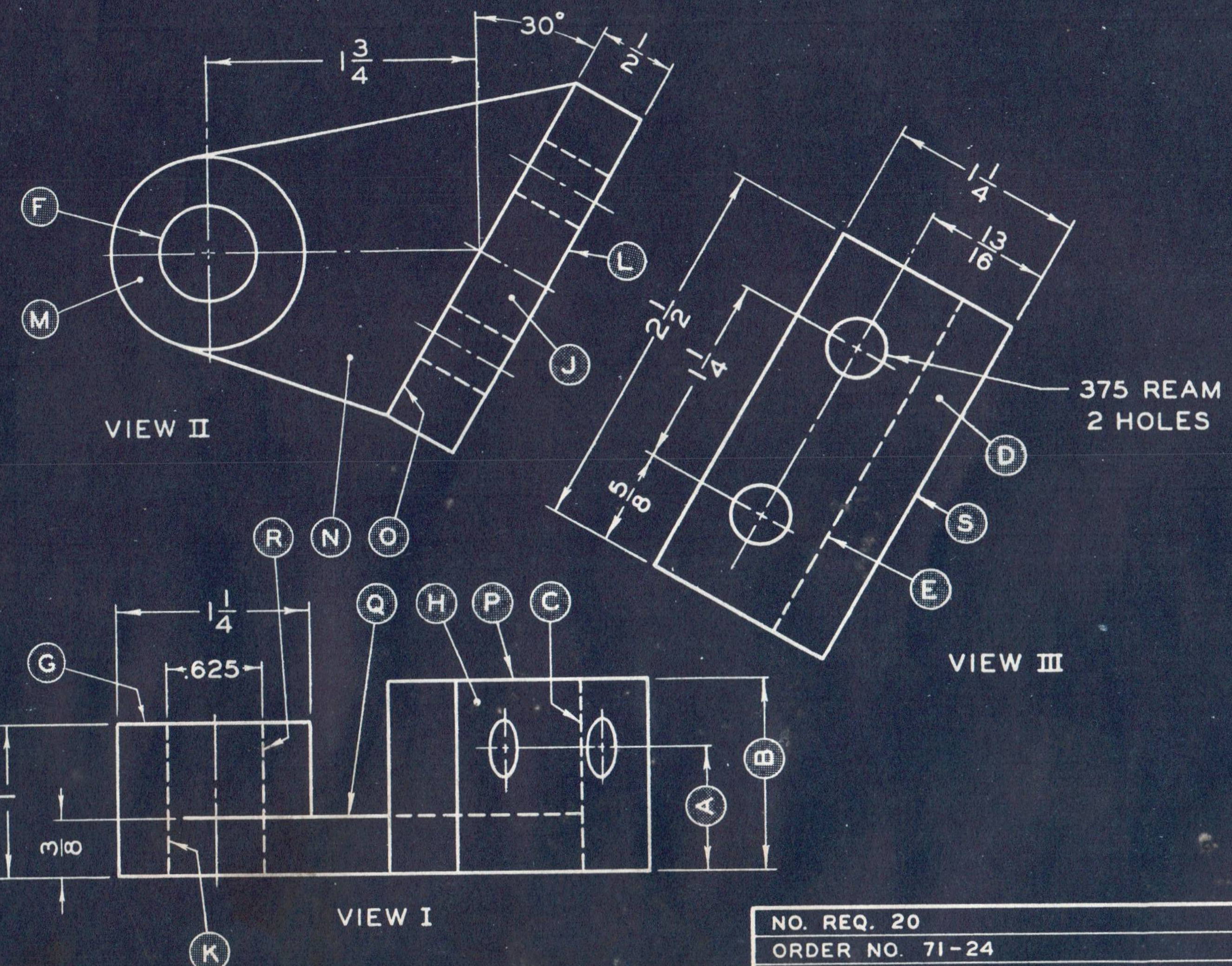


FIG. 36 APPLICATION OF AN AUXILIARY VIEW

The draftsman develops this view by projecting lines (1), (2), (3), (4) and (5) at right angles to surface (A). By comparing the front view with the auxiliary partial view, the hole in surface (A) appears as an ellipse. The width of this surface is foreshortened in the regular view while the true shape and size are shown on the auxiliary view.

The combination of LEFT SIDE VIEW, AUXILIARY PARTIAL TOP VIEW and FRONT VIEW, when properly dimensioned, show all surfaces in their true size and shape. These are the only views needed for this part.


375 REAM
2 HOLES
VIEW II
VIEW III
VIEW I
30°
.625
NO. REQ. 20
ORDER NO. 71-24
MAT'L. MALLEABLE CAST IRON
SHAFT SUPPORT
BP-10

SHAFT SUPPORT (BP-10)

1. What material is the part made of?
2. How many pieces are required?
3. What is the order number?
4. Name each of the following: Views I , II , III
5. What kind of line is (C) ?
6. What kind of line is (P) ?
7. Give the diameter of hole (F) .
8. Determine dimension (A) .
9. Determine dimension (B) .
10. What surface in the front view is the same as surface (D) in the auxiliary view?
11. How many holes .375" D have to be reamed in the support?
12. What is the center to center distance of the .375" holes?
13. What surface in the top view is represented by the line (E) in the auxiliary view?
14. What surface in the top view is represented by line (G) in the front view?
15. What line in the top view represents surface (H) in the front view?
16. What line in the front view represents surface (J) in the top view?
17. What do lines (K) and (R) represent?
18. What line in the front view represents surface (N) in the top view?
19. Determine the vertical distance between the surface represented by the line (P) and the surface represented by line (Q) .
20. What is the distance between the surface represented by line (E) and the surface represented by line (S) ?

Assignment Unit 10	Student's Name ________
1. Malleable Cast iron	10. H
2. 20	11. 2
3. 71-24	12. 1 1/4
4. I front V.	13. N
II top V.	14. M
III aux V.	15. L
5. hidden line	16. P
6. object line	17. a hole .625 D
7. .625	18. Q
8. 1 3/16	19. 7/8
9. 1 1/4	20. 3/8

Section III DIMENSIONS AND NOTES

Unit 11 CONSTRUCTION, SIZE AND LOCATION DIMENSIONS

Drawings consist of a series of lines which are used singly or in combination with each other to describe the shape and internal construction of an object or mechanism. However, to construct or machine a part, the blueprint or drawing must include dimensions which indicate exact sizes and locations of surfaces, indentations and holes.

The lines and dimensions, in turn, are supplemented by notes which give such additional information as: the kind of material used, the degree of machining accuracy required, details regarding assembly of parts, and all other data the craftsman needs to know about the part.

THE "LANGUAGE OF DRAFTING"

Throughout this country, manufacturing plants have, in general, adopted a number of drafting room practices that have become standard in order that there will be uniformity in describing each part. To promote the use of these techniques, the American Standards Association has established a set of drafting room standards which are called "the language of drafting".

While these practices, which are widely used throughout industry, vary in some details in different industrial plants, the principles are basically the same. The practices recommended by the A.S.A. for dimensioning and for making notes are followed in this section.

All drawings should be dimensioned so completely that a minimum of computation will be necessary and the parts may be built without scaling the drawing. There should not, however, be a duplication of dimensions unless such dimensions make the drawing clearer and easier to read.

Many parts cannot be drawn full size because they may be too large to fit a standard drawing sheet, or too small to have all details shown clearly. However, the draftsman is still able to represent such objects by simply reducing or enlarging (as the case may require) the size to which the drawing is made.

This practice does not affect any dimensions as the dimensions on a drawing give the actual sizes. If a drawing 6" long represents a part 12" long, a note may appear anywhere on the drawing or in the title box to indicate the "scale" that is used. This scale is the ratio of the drawing size to the actual size of the object. In this instance, the scale 6" = 12" is frequently referred to as "half scale" or 1/2" = 1". Other common scales include the one-quarter scale (1/4" = 1"), one-eighth scale (1/8" = 1"), and a double size scale where 2" = 1".

CONSTRUCTION DIMENSIONS

Dimensions used in building a part are sometimes referred to as "construction dimensions". Such dimensions serve two purposes: (1) they indicate size and (2) they give exact locations. For example, to drill a through hole in a part, the mechanic must know two things: (1) the diameter of the hole and (2) the exact location of the center (Fig. 37).

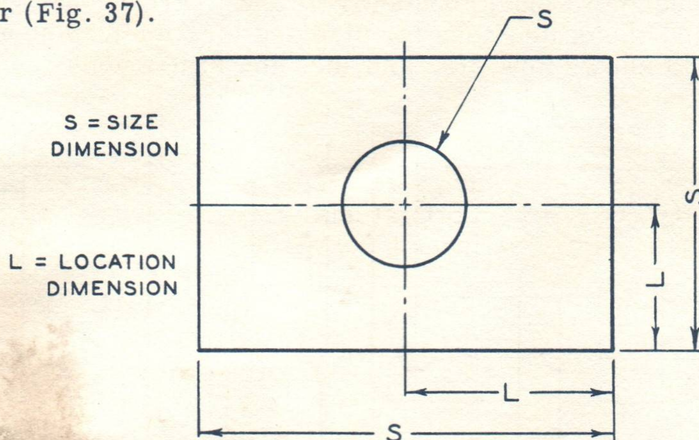


FIG. 37 DIMENSIONS INDICATING SIZE AND LOCATION

SIZE DIMENSIONS

Every solid has three dimensions: length, width and thickness. In the case of a regular prism, two of the dimensions are usually placed on the principal view and the third dimension on one of the other views (Fig. 38).

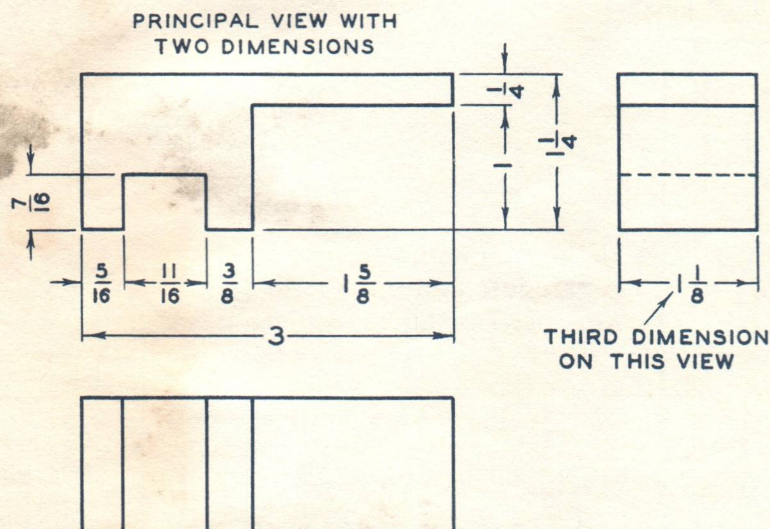


FIG. 38 PLACING SIZE DIMENSIONS

LOCATION DIMENSIONS

Location dimensions are usually made from either a center line or a finished surface. This practice is followed to overcome inaccuracies from variations in measurement caused by surface irregularities.

Draftsmen and designers must constantly follow a part through various stages of manufacture so that the dimensions for size and location furnish all the needed information. Fig. 39 shows how size and location dimensions are indicated.

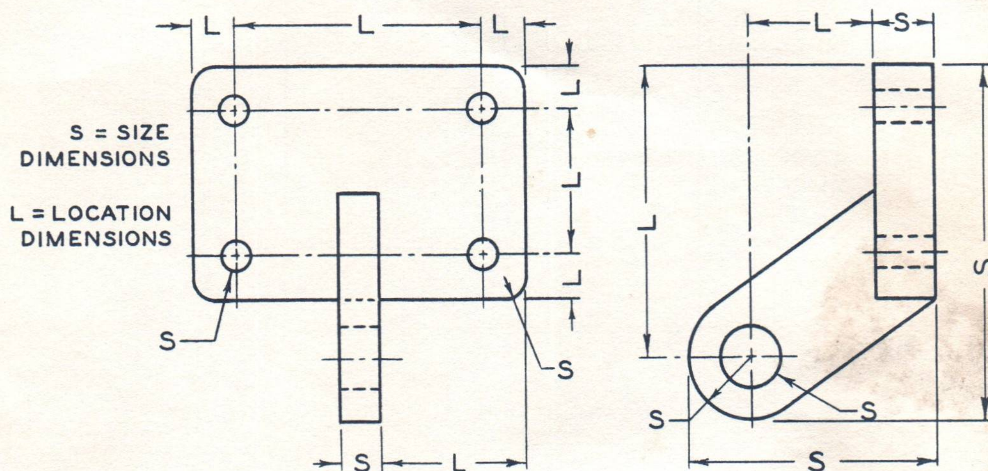


FIG. 39 SIZE AND LOCATION DIMENSIONS

PLACING DIMENSIONS

In dimensioning a drawing, the first step is to place extension lines and external center lines where needed.

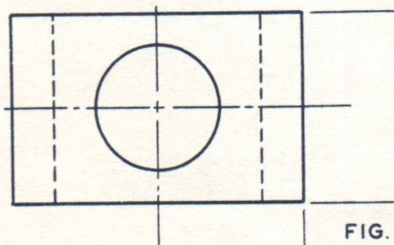
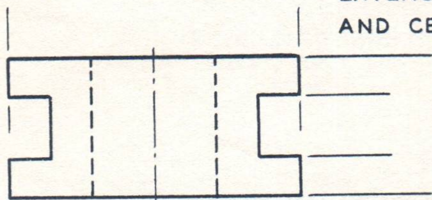


FIG. 40 PLACING EXTENSION LINES AND CENTER LINES



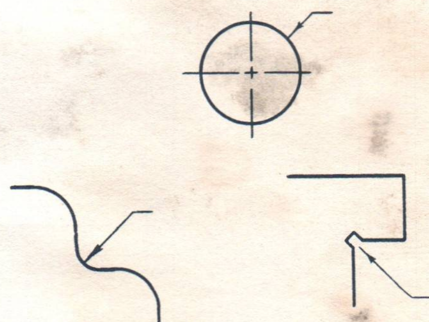


FIG. 41 LEADERS USED FOR DIMENSIONING

Dimension lines and leaders are added next. The term "leader" refers to a light straight line terminating in an arrowhead. The "leader" directs attention to a dimension. A few sample leaders are given in Fig. 41. The arrowhead identifies the surface to which the dimension refers.

Dimensions are kept outside the outline of the object unless they add to the clearness of the drawing. Where a dimension applies to two views, it should be placed between the views as illustrated in Fig. 42. On average size drawings, dimension lines should be placed about 1/4" from each other.

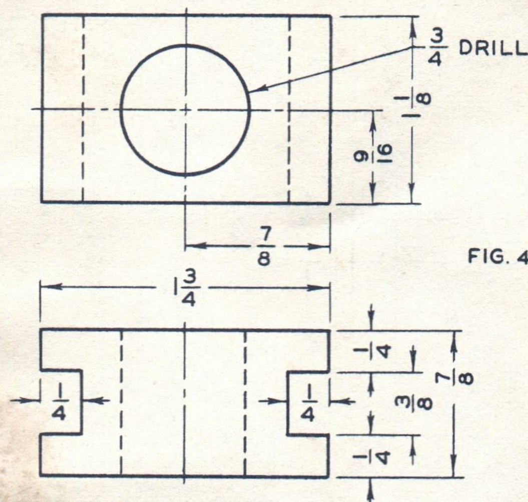
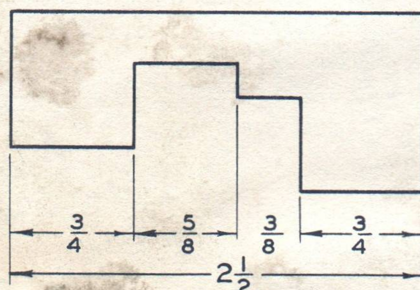
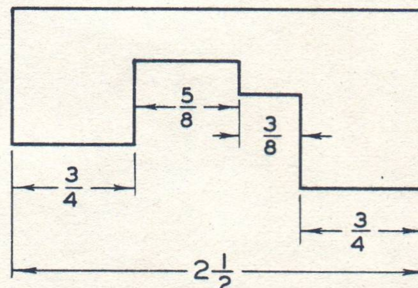


FIG. 42 PLACING DIMENSIONS BETWEEN VIEWS

Where a series of dimensions are required, they should be placed in a line as continuous dimensions. This method is preferred over the staggering of dimensions because of ease in reading, appearance and simplified dimensioning (Fig. 43).



CONTINUOUS DIMENSIONS
(A) PREFERRED METHOD



STAGGERED DIMENSIONS
(B) NOT RECOMMENDED

FIG. 43 PLACING SERIES DIMENSIONS

DIMENSIONS IN LIMITED SPACES

Where grooves or slots are to be dimensioned, the dimension, in many cases, extends beyond the width of the extension line. In such instances, the dimension is placed on either side of the extension line, or a leader is used (Fig. 44).

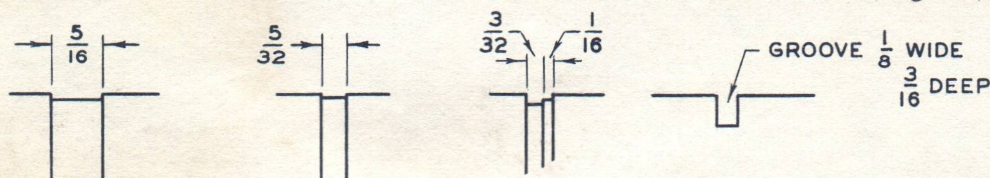
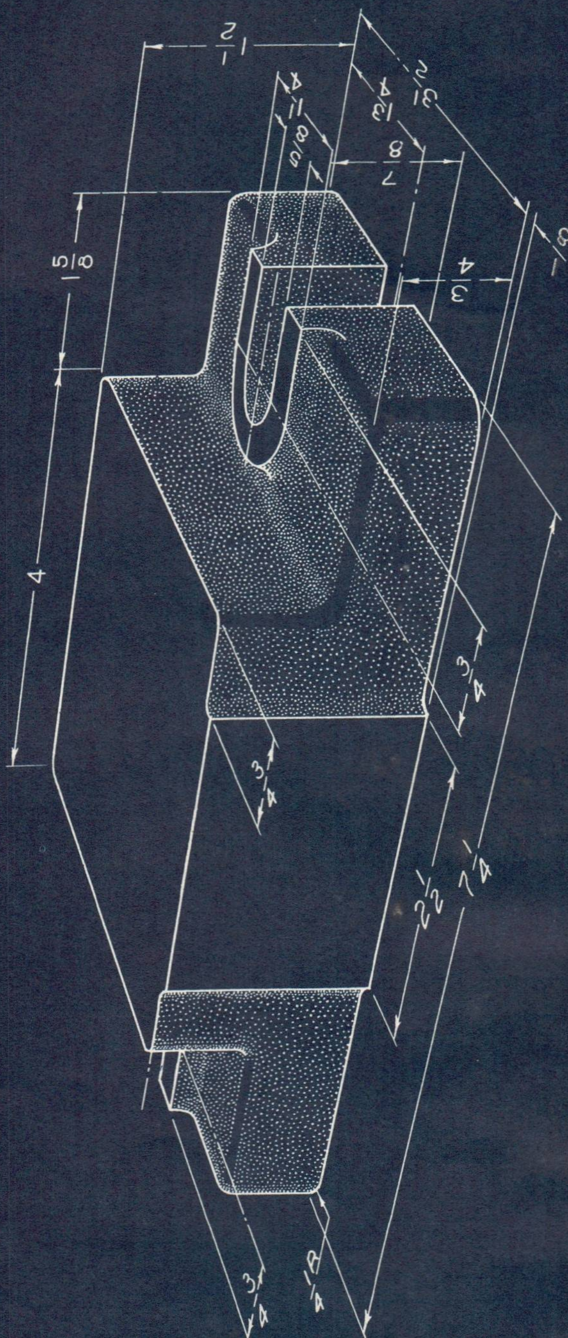
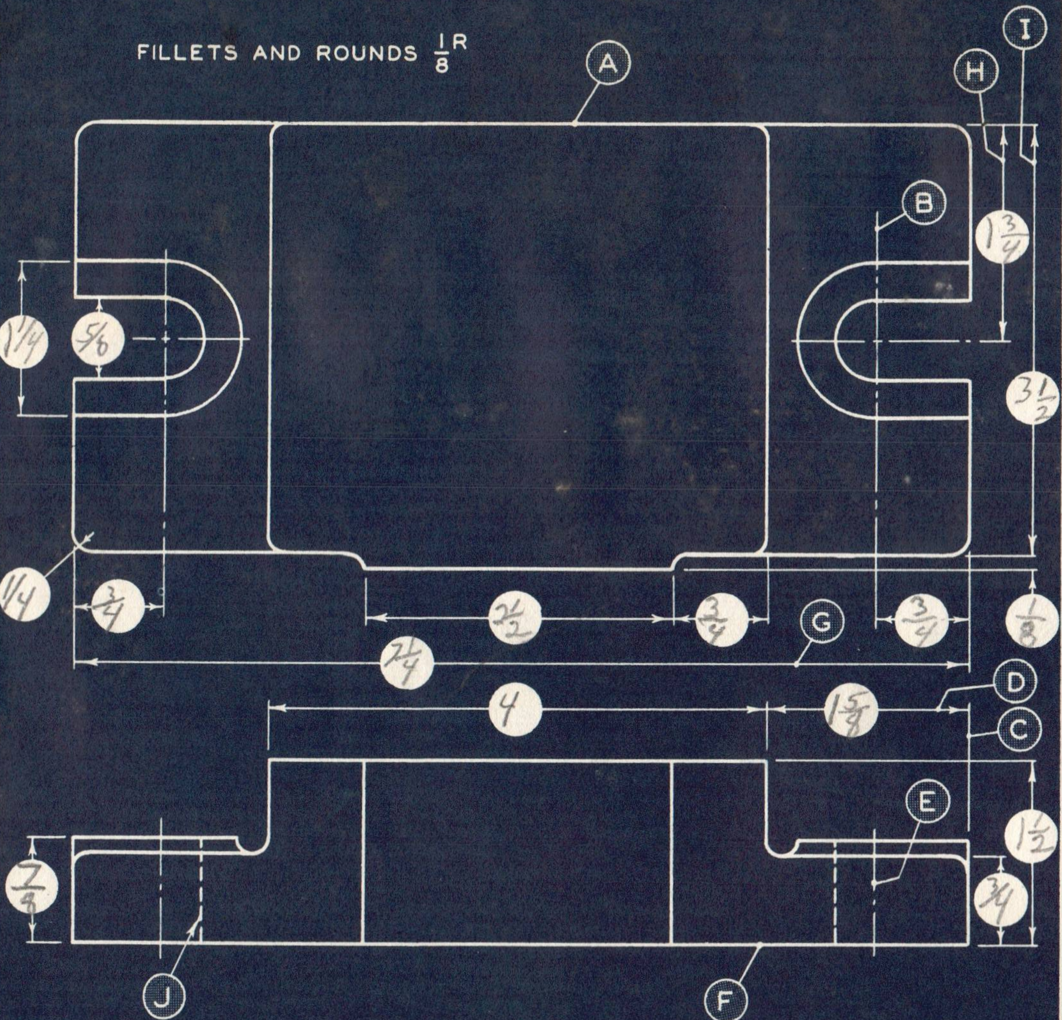


FIG. 44 DIMENSIONING GROOVES AND SLOTS IN LIMITED SPACES



MATERIAL: GRAY CAST IRON	QTY. REQ'D. 10
ORDER NO. 10-51-17A	
PART NO. CASTING 2L 715	
DIE SHOE	BP-11

ADAPTED FROM "DRAFTING SIMPLIFIED" BY ELMER A. ROTMANS



Assignment

Unit 11

Student's Name

NOTE: STUDY THE SKETCH OF THE DIE SHOE

1. Give the dimensions in both views in the circles provided.

2. Indicate one letter on the two-view drawing which identifies each of the following types of lines:

   a. Extension ______ C
   b. Dimension ______ F
   c. Object ______ A
   d. Center line ______ B
   e. Hidden edge ______ J

3. Place an ☒ in the correct block for identifying the kind of dimension each letter refers to.

Dimension	Size Dimension	Location Dimension
(G) is a	dimension	line
(H) is a	location	line
(I) is a	dimension	lines

Unit 12 READING DIMENSIONS - DIMENSIONING CYLINDERS, CIRCLES AND ARCS

READING DIMENSIONS

Dimensions should be placed so that they are readable either from the bottom or the right side of the drawing. Dimensions in inclined positions should be placed so they may be read with a minimum of effort as shown in Fig. 45.

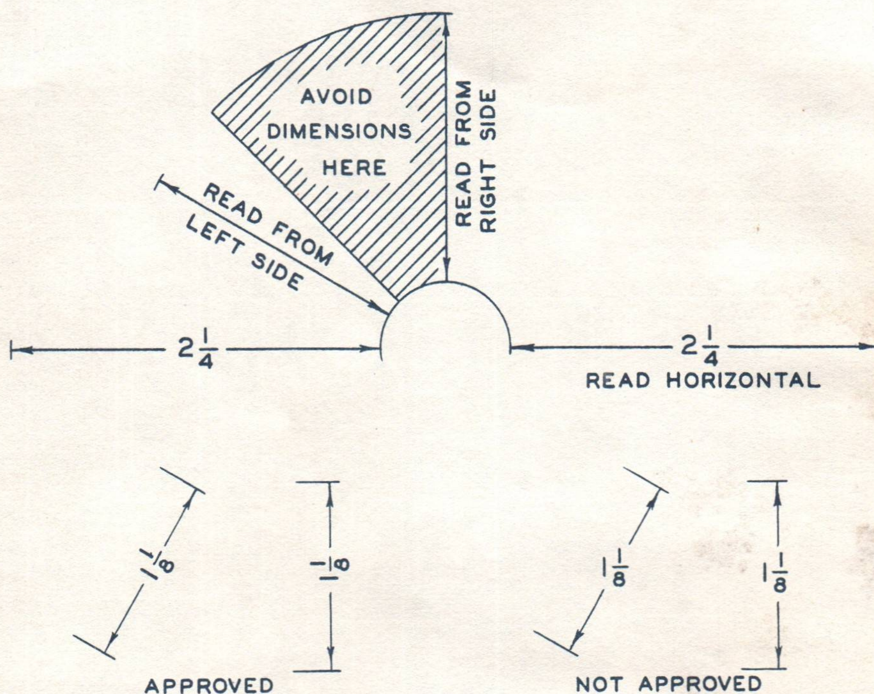


FIG. 45 PLACING DIMENSIONS IN INCLINED POSITIONS

DIMENSIONING CYLINDERS

The length and diameter of a cylinder are usually placed in the rectangular view as shown in Fig. 46. This method is preferred because on small diameter cylinders and holes a dimension placed in the hole would be confusing.

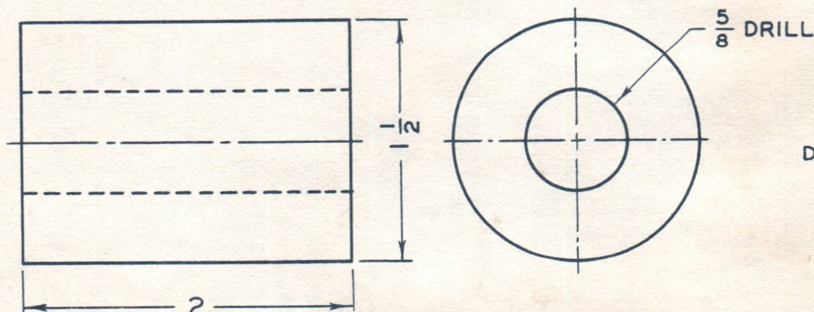
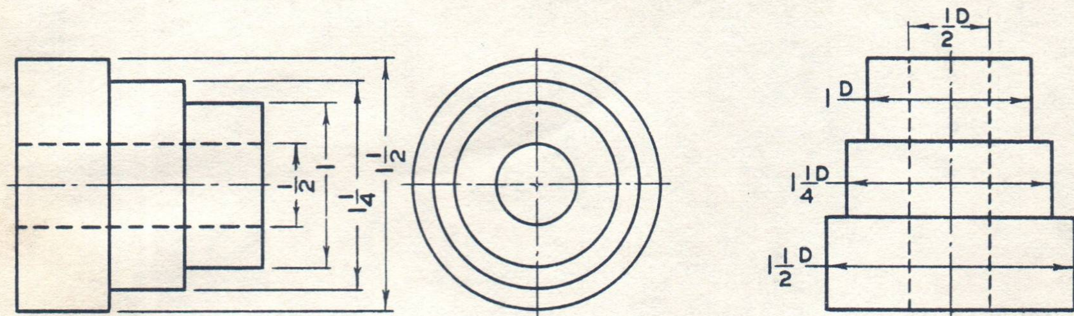


FIG. 46 DIMENSIONING CYLINDERS

Many round parts, with cylindrical surfaces symmetrical about the axis, are represented on one-view drawings. The 'D' is used with the dimension in such instances because no other view is needed to show the shape of the surface. On two-view drawings, the 'D' may be omitted. In other words, when a cylinder is dimensioned, the letter 'D' should follow the dimension unless it is evident that the dimension refers to a diameter (Fig. 47).



CYLINDRICAL SHAPE EVIDENT FROM RIGHT VIEW

FIG. 47 DIMENSIONING CIRCLES

DIMENSIONING ARCS

An arc is always dimensioned by giving the radius. The dimension should be followed by an 'R' and should have an arrowhead only at the outer end (Fig. 48).

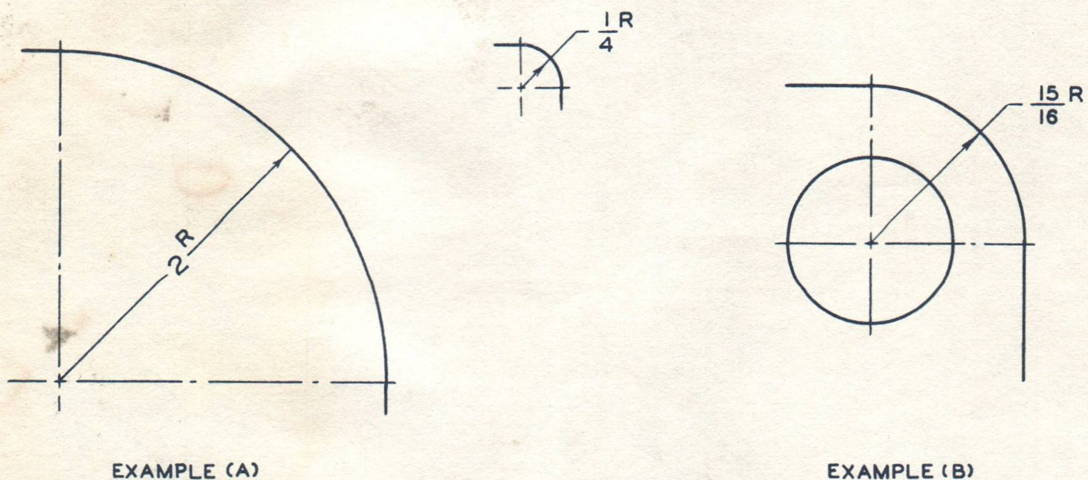
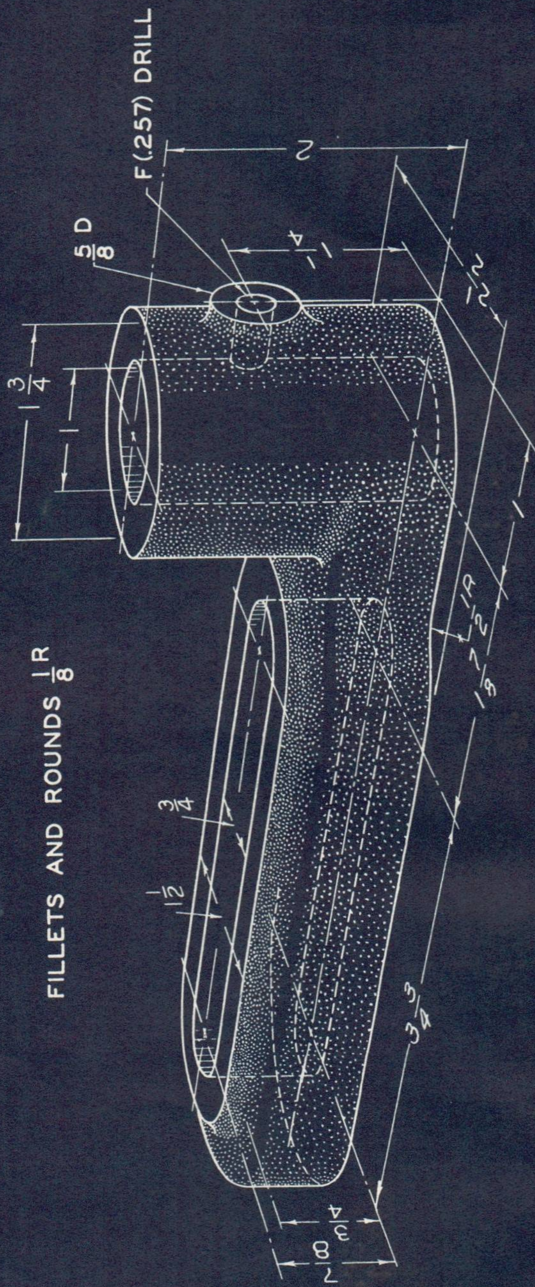
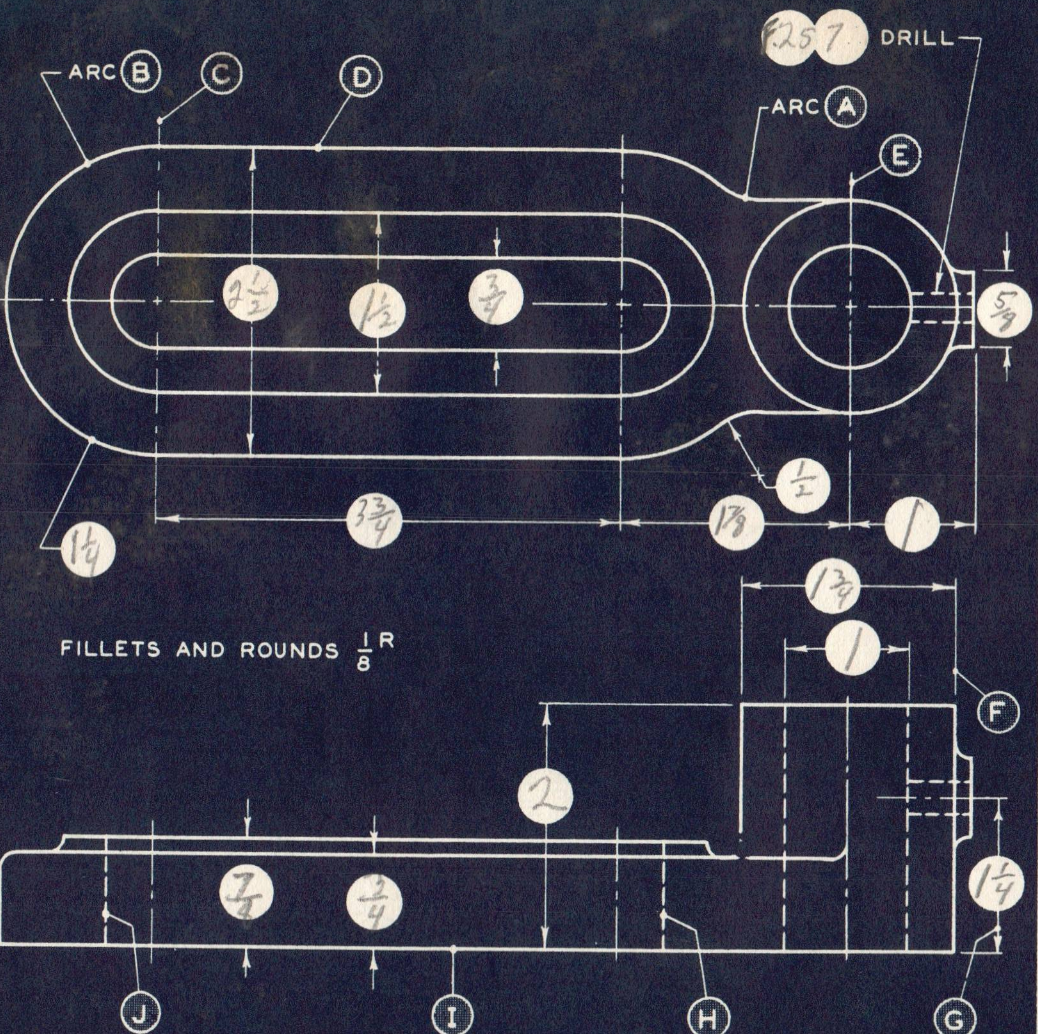


FIG. 48 DIMENSIONING ARCS



MATERIAL: S.A.E. 1040	QTY. REQ'D. 250
ORDER NO. 16-37L	
PART NO. FORGING 37 L	
GEAR ARM	BP-12

ADAPTED FROM "DRAFTING SIMPLIFIED" BY ELMER A. ROTMANS



Assignment

Unit 12

Student's Name

NOTE: STUDY THE SKETCH OF THE GEAR ARM

1. Give the dimensions of both views in the circles provided.
2. Dimension arcs (A) and (B).
3. What is the outside diameter of the upright portion? 1 3/4
4. Give the overall length of the elongated slot. 4 1/2
5. Determine the overall length of the Gear Arm. 7 7/8
6. Name the two views. front and top views.
7. Refer to the two-view drawing. Give one letter which identifies each type of line.
   a. Center line C
   b. Object line D
   c. Extension line F
   d. Hidden edge H
   e. Dimension line G

Unit 13 DIMENSIONING HOLES AND ANGLES

DIMENSIONING HOLES

The diameters of holes which are to be formed by drilling, reaming or punching should have the diameter, preferably on a leader, followed by a note indicating (1) the operation to be performed and (2) the number of holes to be produced (Fig. 49).

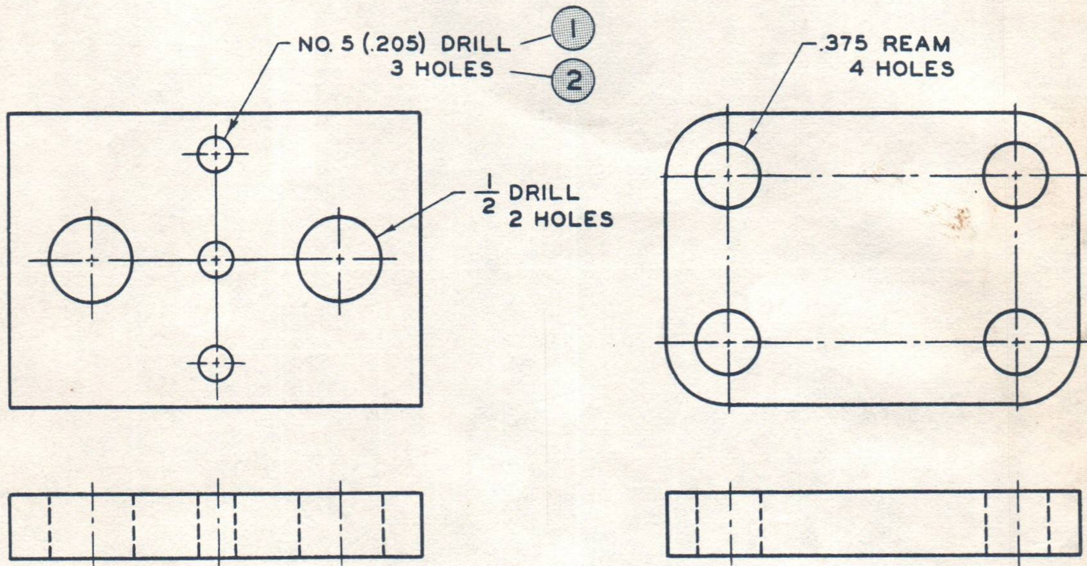


FIG. 49 DIMENSIONING HOLES

DIMENSIONING COUNTERBORED HOLES

A counterbored hole (Fig. 50) is one that has been machined to a larger diameter for a distance that will permit a bolt or pin to fit into this recessed hole. Also, the counterbored hole provides a flat surface for the bolt or pin to seat against.

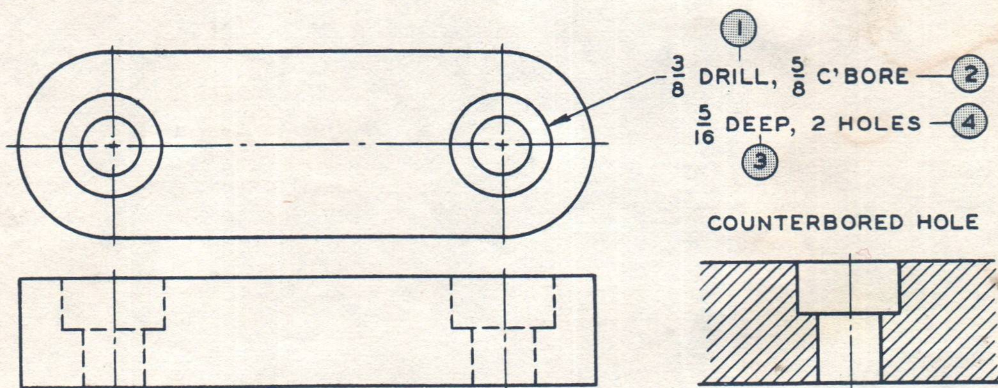


FIG. 50 DIMENSIONING COUNTERBORED HOLES

Counterbored holes are dimensioned by giving (1) the diameter of the drill, (2) the diameter of the counterbore, (3) the depth and (4) the number of holes (Fig. 50).

DIMENSIONING COUNTERSUNK HOLES

A countersunk hole (Fig. 51 at (A)) is a cone-shaped recess machined in a part to receive a cone-shaped flat head screw or bolt.

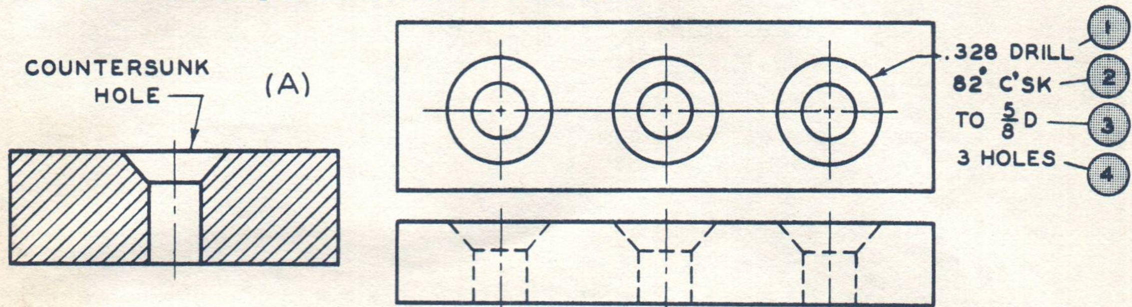


FIG. 51 DIMENSIONING COUNTERSUNK HOLES

Countersunk holes are dimensioned by giving (1) the diameter of the hole, (2) the angle at which the hole is to be countersunk, (3) the diameter at the large end of the hole and (4) the number of holes to be countersunk.

DIMENSIONING ANGLES

The design of a part may require some lines to be drawn at an angle. The amount of the divergence (i.e. the lines move away from each other) is indicated by an angle measured in degrees or fractional parts of a degree. The degree is indicated by the symbol (°) placed after the numerical value of the angle like 45° which indicates that the angle measures 45 degrees.

Two common methods of dimensioning angles are (1) in terms of linear dimensions and (2) angular measure as illustrated at (A) and (B) in Figure 52.

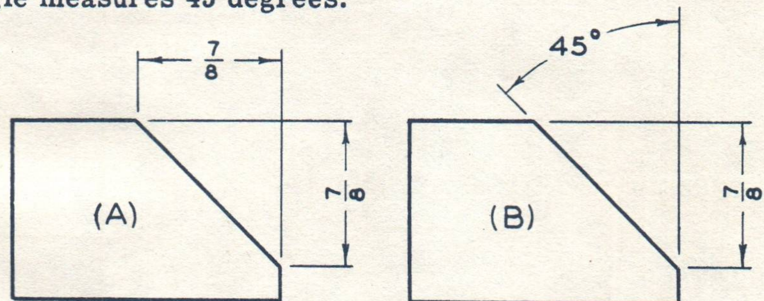


FIG. 52 METHODS OF DIMENSIONING ANGLES

The dimension line for an angle should be an arc whose ends terminate in arrowheads. The numeral indicating the number of degrees in the angle is read in a horizontal position except where the angle is large enough to permit the numerals to be placed along the arc (Fig. 53).

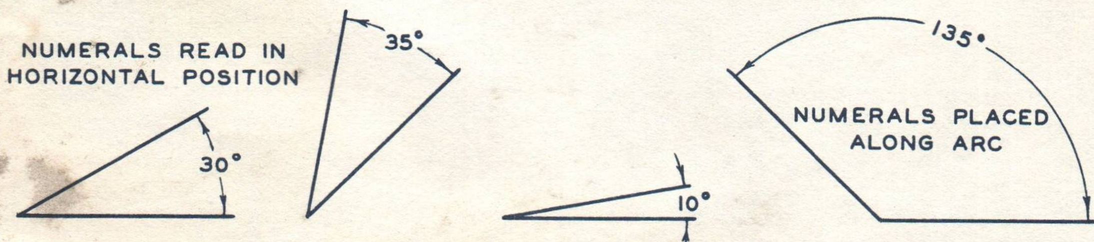
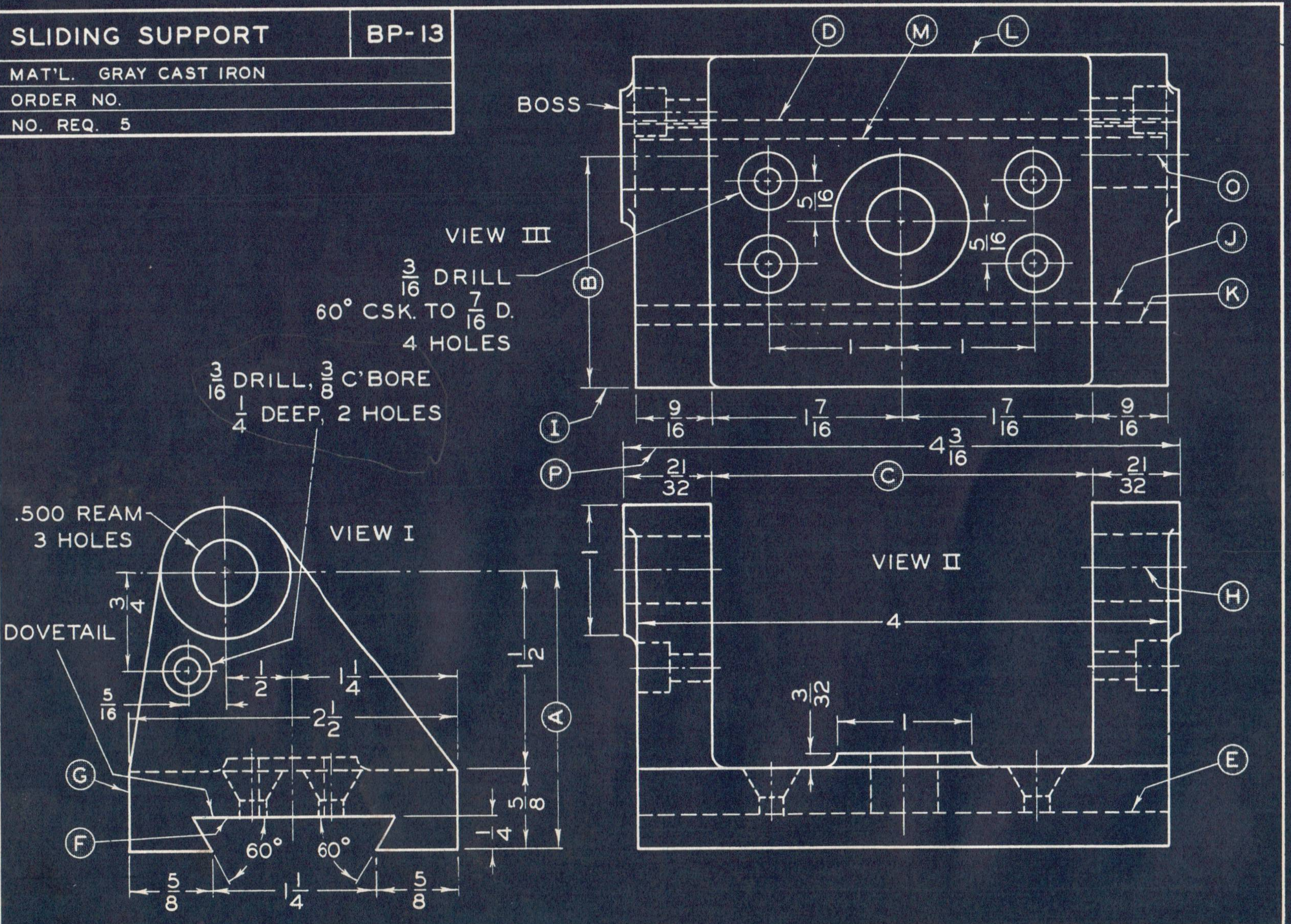


FIG. 53 PLACING ANGULAR DIMENSIONS


SLIDING SUPPORT
BP-13
MAT'L. GRAY CAST IRON
ORDER NO.
NO. REQ. 5
BOSS
VIEW III
3/16 DRILL
60° CSK. TO 7/16 D.
4 HOLES
3/16 DRILL, 3/8 C'BORE
1/4 DEEP, 2 HOLES
.500 REAM
3 HOLES
VIEW I
DOVETAIL
VIEW II

SLIDING SUPPORT (BP-13)

1. Name the view I which shows the shape of the dovetail.
2. Name the view III in which the bottom pad appears as a circle.
3. Name view II
4. Name the kind of line shown at (E).
5. What surface in view I is represented by line (E) ?
6. Name the kind of line shown at (G).
7. What line in view III represents surface (G) ?
8. Name the kind of line shown at (H).
9. What line in view III represents the line (H) ?
10. Name the kind of line shown at (I).
11. Name the kind of line shown at (J).
12. What lines in the top view represent the dovetail?
13. What does the line (E) in the front view represent?
14. Determine height (A).
15. How many bosses are shown on the uprights?
16. What is the outside diameter of the boss?
17. Determine dimension (B).
18. How far off from the center of the support is the center of the two holes in the uprights?
19. Give the dimensions for the counterbored holes.
20. What dimensions are given for the countersunk holes?
21. Give the dimensions of the reamed holes.
22. What is the dimension (C) ?
23. How wide is the opening in the dovetail?
24. How deep is the dovetail machined?
25. State the angle to the horizontal at which the dovetail is cut.

Assignment Unit 13	Student's Name

1. L. side	14. 2 1/8
2. top V.	15. 2
3. front	16. 1
4. hidden line	17. 1 3/4
5. F	18. ~~3/4~~ 1/2
6. object line	19. 3/16 D. 3/8 C'bore 1/4 deep 2 holes
7. ~~K~~ L	20. 3/16 Drill 60° csk 7/16 D 4 holes
8. center line	21. .500 ream 3 holes
9. O	22. 2 7/8
10. extension line	23. 1 1/4
11. hidden line	24. 1/4
12. J K D M	25. 60°
13. hidden surface	

Unit 14 DIMENSIONING CENTERS AND HOLES ON A CIRCLE

DIMENSIONING A POINT OR A CENTER

When a point or the center of a circle or an arc is to be located, it is preferable, and in many cases simpler, for the craftsman to make measurements from two finished surfaces rather than to attempt to make an angular measurement.

In Figure 54, the center of the circle and arc may be found easily by scribing the vertical and horizontal center lines from the machined surfaces.

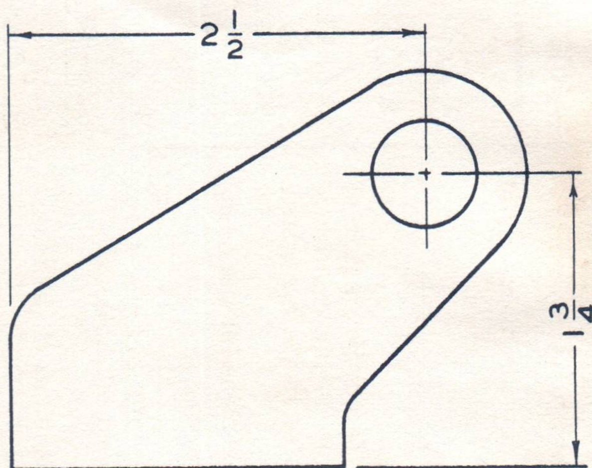


FIG. 54 DIMENSIONING THE CENTER OF A CIRCLE

DIMENSIONING EQUALLY SPACED HOLES ON A CIRCLE

Where holes are equally spaced on a circle, the exact location of the first hole is given. The location dimensions are then followed by (1) the diameter of the holes, (2) the number of holes and (3) the notation "equally spaced" (Fig. 55).

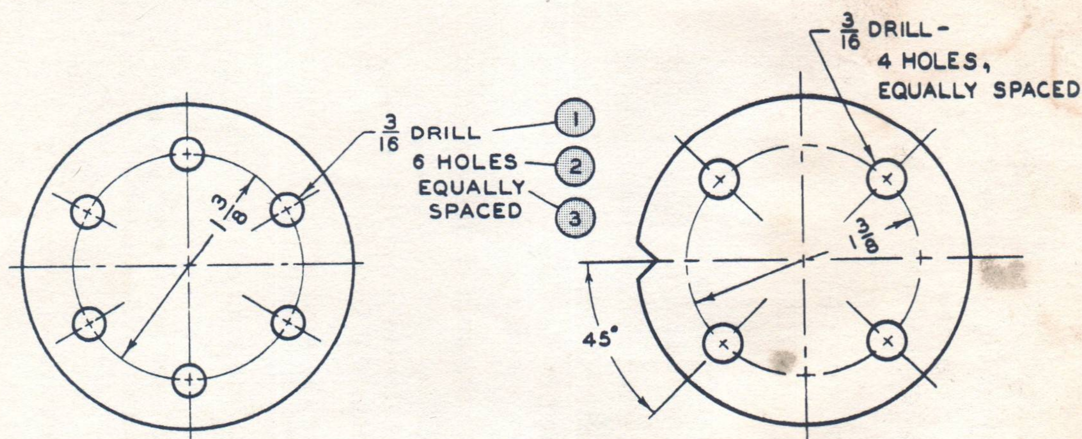
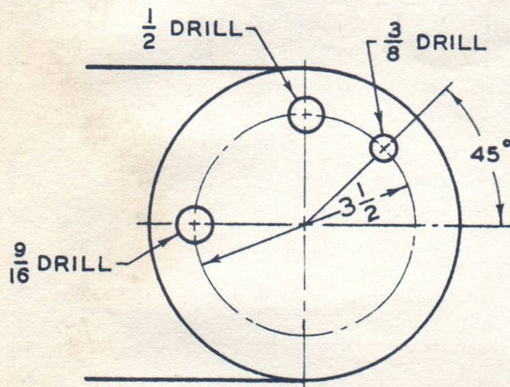


FIG. 55 DIMENSIONING HOLES EQUALLY SPACED ON A CIRCLE

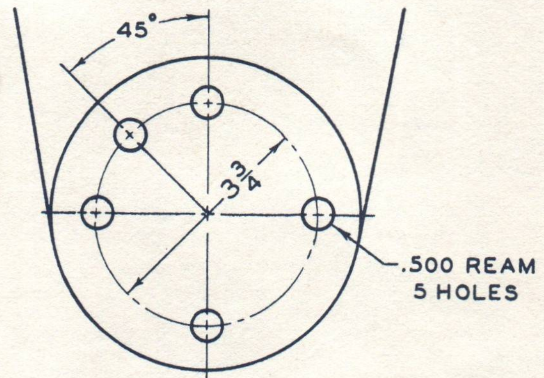
DIMENSIONING UNEQUALLY SPACED HOLES ON A CIRCLE

When holes are to be located on a circle, the diameter of the circle should be given so as to fix the exact center. The size of each hole and position are noted on the drawing (Fig. 56 at A). If more than one hole is the same diameter, then a notation may be used to indicate this fact (Fig. 56 at B).

For example, the notation .500 REAM - 5 HOLES means that the five holes on the drawing are reamed 1/2" in diameter.



(A) POSITION AND SIZE OF EACH HOLE GIVEN



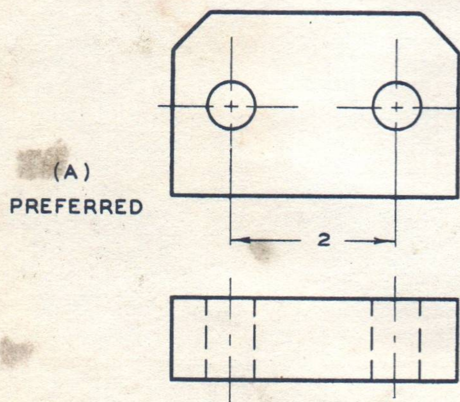
(B) NOTATION WHERE HOLES ARE SAME SIZE

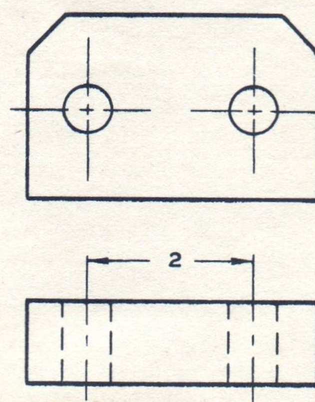
FIG. 56 TWO METHODS OF DIMENSIONING UNEQUALLY SPACED HOLES ON A CIRCLE

DIMENSIONING HOLES NOT ON A CIRCLE

Holes are often dimensioned in relation to one another or to a finished surface, rather than from a common center. Dimensions are usually given, in such cases, in the view which shows the shape of the holes as square, round or elongated. The preferred method of placing these dimensions is illustrated below at (A).

(A) PREFERRED





(B) POOR PRACTICE

PLACING DIMENSIONS FOR HOLES

K O J N

60°

$\frac{11}{32}$ DRILL
7 HOLES
EQUALLY
SPACED

$2\frac{5}{8}$

.375 REAM
4 HOLES

A B

$3\frac{3}{4}$

30°

I

$3\frac{1}{4}$

1.000 BORE

H G F E C D

$1\frac{3}{4}$

$\frac{1}{8}$ R

$\frac{3}{8}$

$1\frac{1}{8}$

2

$\frac{1}{2}$

$\frac{5}{8}$

$1\frac{1}{4}$

$4\frac{1}{2}$

COUPLING	BP-14

COUPLING (BP-14)

1. Name the view which shows the width of the Coupling.
2. Name the view in which the holes are shown as circles.
3. Name the kind of line shown at

   (E) (G) (I)
   (F) (H) (J)

4. What circle represents the 4-1/2" diameter flange?
5. What circle represents the 1" bore diameter?
6. Name the kind of line shown at (N).
7. How many holes are to be drilled in the larger flange?
8. Indicate the drill size to be used.
9. Give the diameter circle on which the equally spaced holes are drilled in the larger flange.
10. How many holes are to be reamed in the smaller flange?
11. How deep is the 1-1/4" D hole bored?
12. Give the diameter of the reamed holes.
13. State the angle with horizontal center line used for locating the first reamed hole.
14. What is the overall width of the Coupling?
15. What is the diameter of the smallest flange?
16. What is the diameter of the circle (A)? circle (B)?
17. What is the length of the 1" bored hole?
18. What is the thickness of the largest flange?
19. If a 5/16" bolt is used in the drilled holes, what will be the clearance between the hole and the bolt?
20. Determine distances (C), (D)

Assignment Unit 14	Student's Name ___________

1.	front V.	9.	3 3/4
2.	top V.	10.	4
3. (E)	dimension	11.	5/8
(F)	center	12.	.375 Ream
(G)	hidden	13.	60°
(H)	extension	14.	~~4 1/2~~ 2
(I)	object	15.	3 1/4
(J)	center	16. (A)	1 1/4
		(B)	~~2~~ 1 3/4
4.	O	17.	1 3/8
5.	~~A~~ K	18.	1/2
6.	dimension	19.	1/32
7.	~~4~~ 7	20. (C)	3/4
8.	11/32	(D)	1 3/8

Unit 15 DIMENSIONING LARGE ARCS AND BASE LINE DIMENSIONING

DIMENSIONING ARCS WITH CENTERS OUTSIDE THE DRAWING

When the center of an arc falls outside the limits of the drawing, a broken dimension line is used as illustrated in Figure 57. This dimension line gives the size of the arc and indicates that its center lies in a center line outside the drawing.

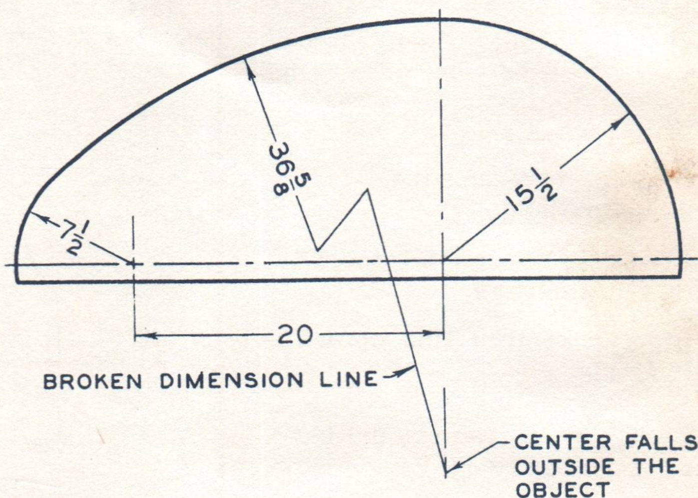


FIG. 57 USING BROKEN DIMENSION LINE

BASE LINE DIMENSIONING

In base line dimensioning, all measurements are made from common finished surfaces called "base lines" or "reference lines". Base line dimensioning is used where accurate layout work to precision limits is required. With this method of dimensioning, all measurements are taken from the base lines so that errors are not cumulative.

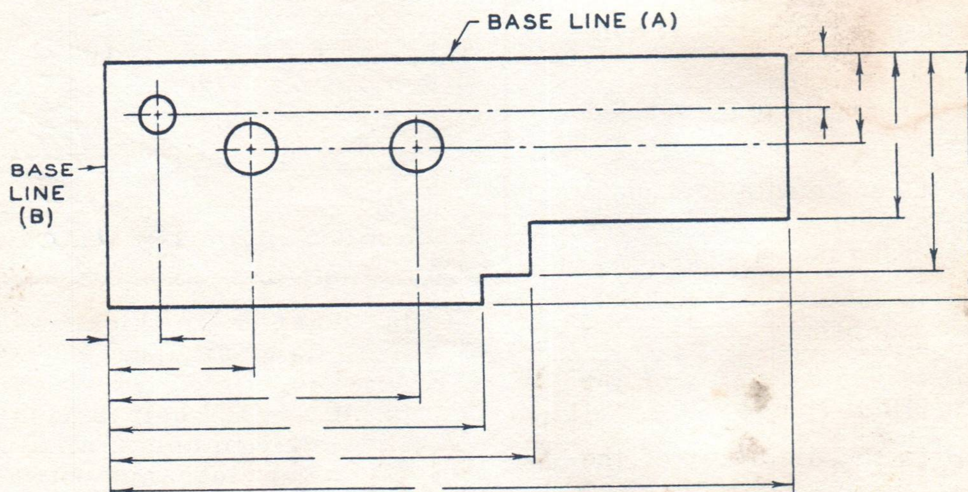
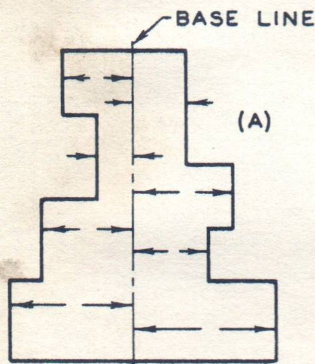


FIG. 58 BASE LINE DIMENSIONING FROM TWO MACHINED EDGES

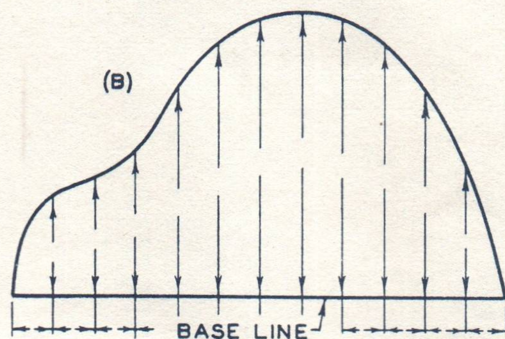
Dimensions and measurements may be taken from one or more base lines. In Figure 58, the two base lines are at right angles to each other.

The horizontal dimensions are measured from base line (B) which is a machined edge. The vertical dimensions are measured from surface (A) which is at right angles to surface (B) and is also a machined surface.

An application of base line dimensioning where a center line is used as a reference line is shown in Figure 59. The method of dimensioning may also be applied to irregular shapes such as the template illustrated in Figure 59 at (B) .



CENTER LINE USED AS BASE LINE



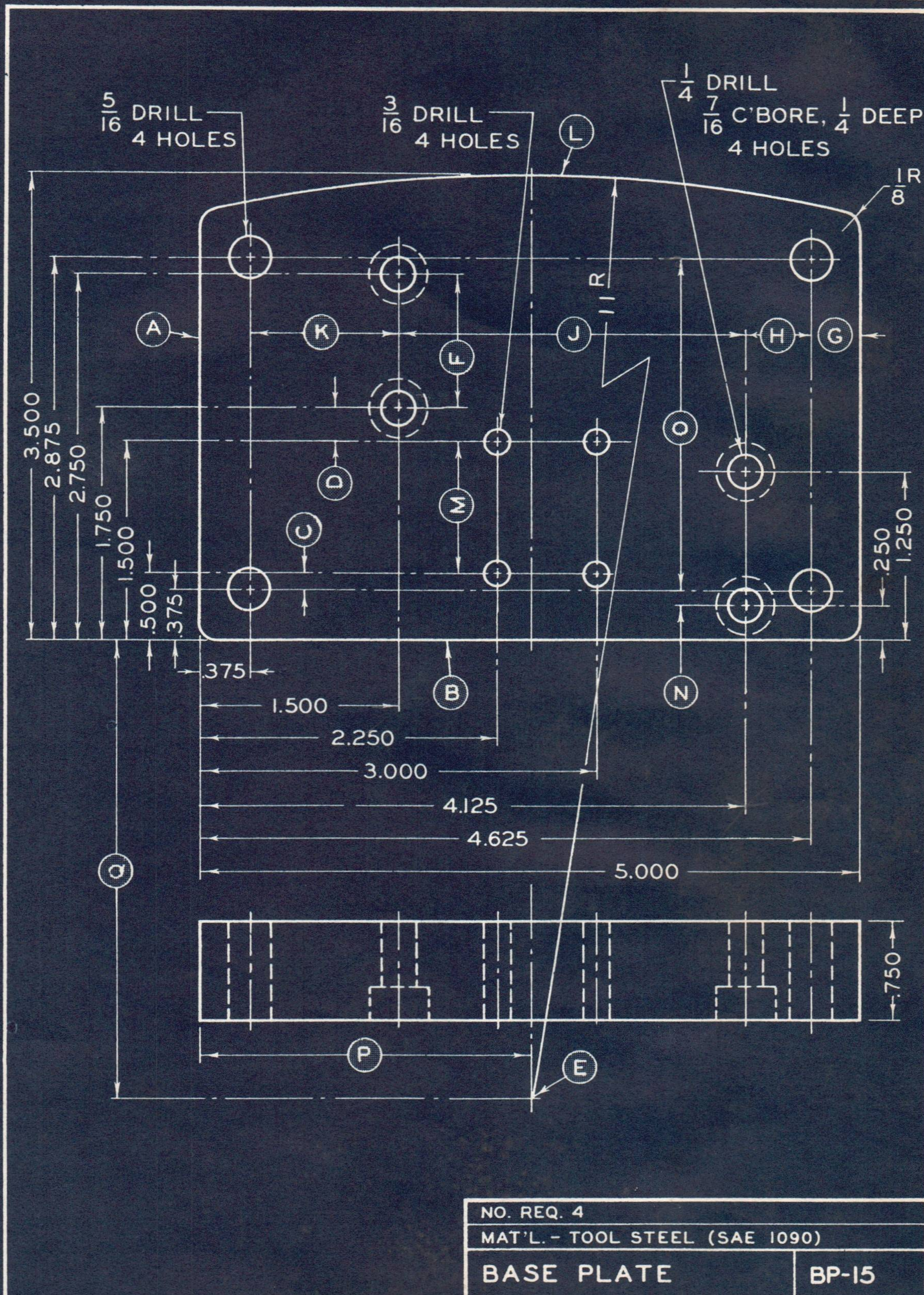
BASE LINE DIMENSIONING APPLIED TO IRREGULAR SHAPE

FIG. 59 APPLICATIONS OF BASE LINE DIMENSIONING

Base line dimensions simplify the reading of a drawing and also permit greater accuracy in making the part.

SHOP DIMENSIONS

In most machine and metal trades shops, dimensions under 72 inches are usually stated in inches. By comparison, measurements for structural work and the building trades are usually given in feet and inches.


5/16 DRILL 4 HOLES
3/16 DRILL 4 HOLES
1/4 DRILL 7/16 C'BORE, 1/4 DEEP 4 HOLES
1/8 R
11 R
A
B
C
D
E
F
G
H
J
K
L
M
N
O
P
Q
3.500
2.875
2.750
1.750
1.500
.500
.375
.375
1.500
2.250
3.000
4.125
4.625
5.000
.250
1.250
.750
NO. REQ. 4
MAT'L. - TOOL STEEL (SAE 1090)
BASE PLATE
BP-15

BASE PLATE (BP-15)

1. Give the name of the part.
2. What material is the part made of ?
3. How many parts are required?
4. What is the length of the Base Plate?
5. What is the width of the Base Plate?
6. What is the thickness of the Plate?
7. How many 5/16" holes are to be drilled?
8. How many 3/16" holes are to be drilled?
9. How many 1/4" holes are to be drilled?
10. Give (a) the diameter and (b) the depth of counterbore for the 1/4" holes.
11. What system of dimensioning is used on this drawing?
12. Give the letter of the base line in the Top View from which all vertical dimensions are taken.
13. Give the letter of the base line in the Top View from which all horizontal dimensions are taken.
14. Compute the following dimensions:
    Ⓒ Ⓓ Ⓜ Ⓕ
15. Compute the horizontal dimensions:
    Ⓖ Ⓗ Ⓙ Ⓚ
16. Compute dimensions Ⓝ and Ⓞ.
17. Give the radius to which the corners are rounded.
18. What is the radius of arc Ⓛ ?
19. What letter indicates the center for arc Ⓛ ?
20. Compute dimensions Ⓟ and Ⓠ.

Assignment Unit 15	Student's Name

1. Base Plate
2. tool steel (SAE 1090)
3. 4
4. ~~3.5~~ 5
5. ~~4~~ 3.5
6. .750
7. 4
8. 4
9. 4
10. 7/16 C bore 1/4 deep
11. base line dimensions
12. ~~A~~ B
13. ~~D~~ A
14. Ⓒ = 1.25 Ⓜ = 1
    Ⓓ = 2.50 Ⓕ = 1
15. Ⓖ = 1.375 Ⓙ = 2.625
    Ⓗ = .500 Ⓚ = 1.125
16. Ⓝ = .125 Ⓞ = 2.500
17. 1/8 R
18. 11 R
19. E
20. Ⓟ = 2.500 Ⓠ = 7.500

Unit 16 TOLERANCES, FRACTIONAL AND ANGULAR DIMENSIONS

TOLERANCES

As a part is planned, the designer gives serious consideration (1) to its function either as a separate unit or one which must move in a fixed position in relation to other parts, (2) the operations required to produce the part, (3) the material, (4) the quantity to be produced and (5) the cost. Each of these factors influences the degree of accuracy to which a part is machined.

The dimensions given on a drawing are an indication of what the limits of accuracy are. These limits are called tolerances. For work which does not require a high degree of accuracy, the drawing may specify the tolerances to which the part may be held in terms of fractional dimensions. More precisely machined parts require that the accuracy be given in terms of decimal tolerances.

SPECIFYING FRACTIONAL TOLERANCES

The note LIMITS ON FRACTIONAL DIMENSIONS ARE $\pm\frac{1}{64}''$ indicates that the dimension given in fractions on the drawing may be machined any size between a 64th of an inch larger or a 64th of an inch smaller than the specified size.

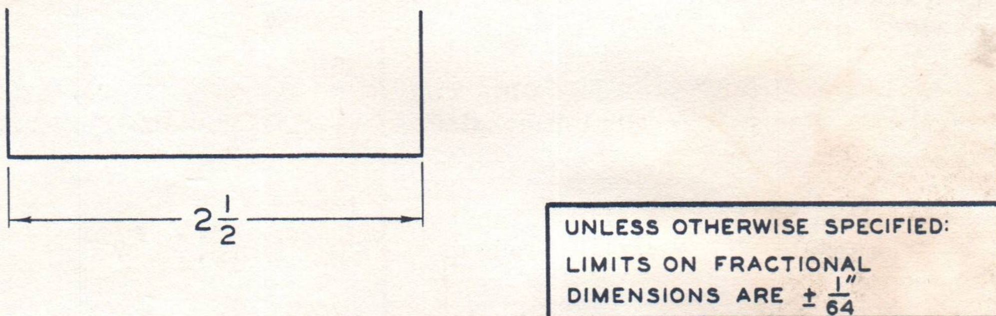


FIG.60 FRACTIONAL TOLERANCES APPLIED

EXAMPLE:

On the $2\frac{1}{2}''$ dimension:

1. The tolerance given on the drawing is $\pm\frac{1}{64}''$
2. The largest size to which the part may be machined is $2\frac{1}{2}'' + \frac{1}{64}'' = 2\frac{33}{64}''$
3. The smallest size to which the part may be machined is $2\frac{1}{2}'' - \frac{1}{64}'' = 2\frac{31}{64}''$

The larger size is called the UPPER LIMIT; the smaller size is referred to as the LOWER LIMIT.

ANGULAR DIMENSIONS

Angles are dimensioned in degrees or parts of a degree.

1. Each degree is one three hundred sixtieth of a circle.
2. The degree may be divided into smaller units called "minutes". There are 60 minutes in each degree.
3. Each unit may be divided into smaller units called "seconds". There are 60 seconds in each minute.

To simplify the dimensioning of angles, symbols are used to indicate degrees, minutes and seconds (Fig. 61).

	SYMBOL
DEGREES	°
MINUTES	′
SECONDS	″

Example: Twelve degrees, sixteen minutes and five seconds would be written:

12° 16′ 5″

FIG. 61 SYMBOLS USED FOR DIMENSIONING ANGLES

SPECIFYING ANGULAR TOLERANCES

The tolerance on an angular dimension may be given in a note on the drawing or on the angular dimension itself. Examples of both methods are illustrated in Figures 62 and 63.

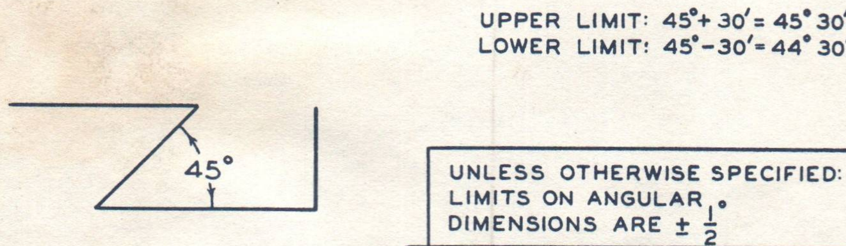


FIG. 62 TOLERANCE SPECIFIED AS A NOTE

TOLERANCE ± 10′

UPPER LIMIT: 60°+ 10′= 60° 10′

LOWER LIMIT: 60° − 10′= 59° 50′

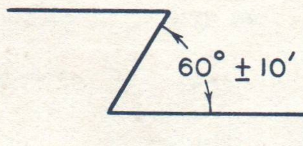
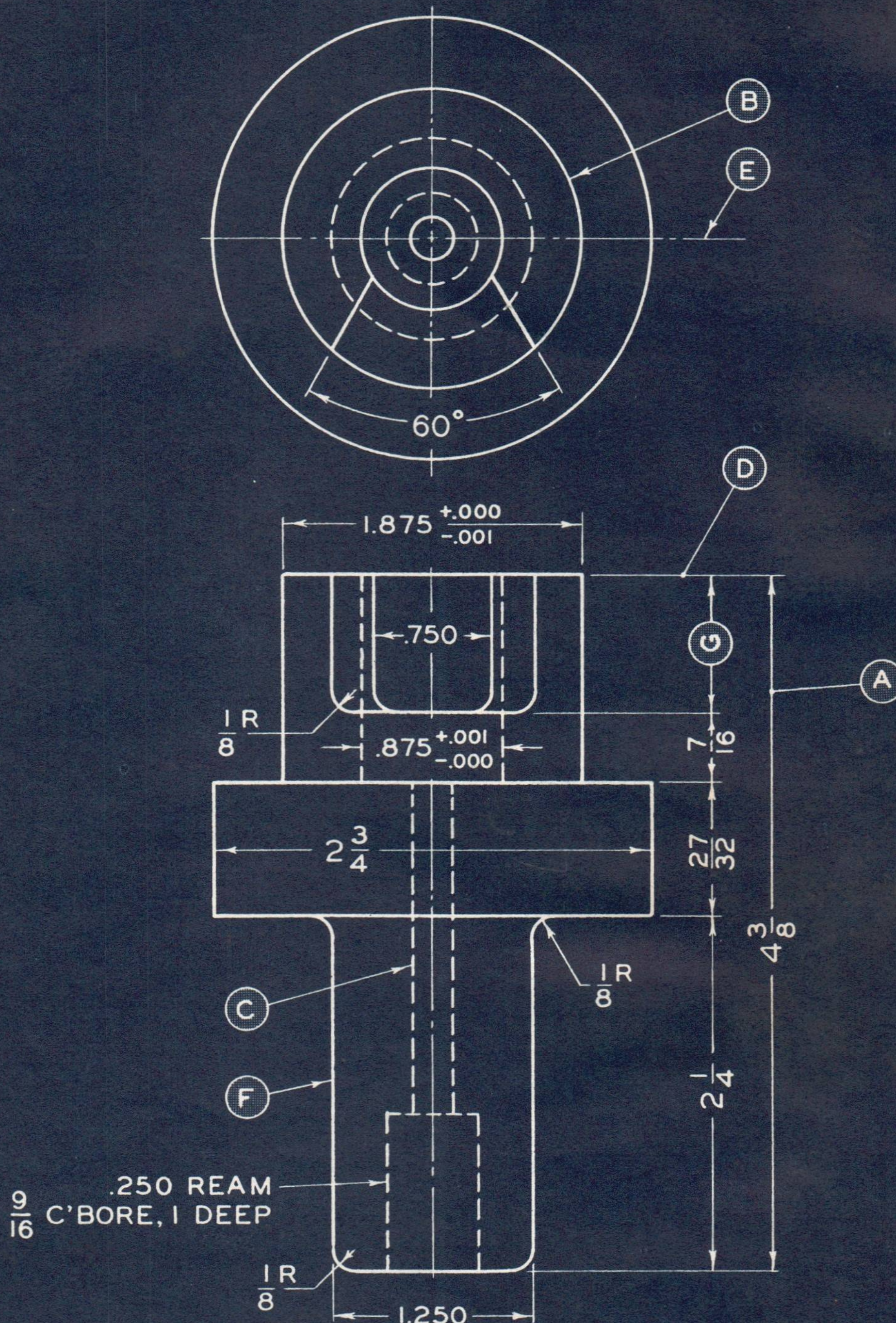


FIG. 63 TOLERANCE SPECIFIED ON ANGULAR DIMENSION



UNLESS OTHERWISE SPECIFIED:
LIMITS ON DECIMAL DIMENSIONS ±.001″
LIMITS ON FRACTIONAL DIMENSIONS ±1/64″
LIMITS ON ANGULAR DIMENSIONS +5′ −0′

ORDER NO. 29M 1602	PART NO. 29M 17	QTY. 2
MAT'L SAE 1090	HEAT TREATMENT SPEC. H 2	
SECTOR PUNCH	BP-16	

SECTOR PUNCH (BP-16)

1. What letter is used to denote a
   a. Hidden edge line
   b. Dimension line
   c. Extension line
   d. Center line
2. Determine dimension (G).
3. What is the diameter of the reamed pilot hole for the counterbore?
4. Give the diameter and depth of the counterbore.
5. What are the upper and lower limits of tolerances for fractional dimensions?
6. What limit of tolerance is specified for angular dimensions?
7. What is the largest size the 2-3/4" diameter can be turned to?
8. What is the lower limit to which the 2-3/4" diameter can be machined?
9. Give the upper limit to which diameter (B) may be machined.
10. Give the upper and lower limit on the diameter for shank (F).
11. If shank (F) is turned to the upper limit length, how long will it be?
12. If shank (F) is machined 2-3/16" long, how much under the lower limit size will it be?
13. How much over the upper limit will the shank be if it is 2-5/16" long?
14. What is the upper limit of accuracy for the 60° angle?
15. If the height of the 1.875 diameter punch measures 1-9/32", is it over, under or within the specified limits of accuracy?

Assignment Unit 16	Student's Name

1. (a) C
   (b) A
   (c) D
   (d) E
2. 27/32
3. .250 Ream
4. Diameter .250 Ream
   Depth 9/16 C'Bore, 1 deep
5. Upper 1/64
   Lower 1/64
6. + 5' − 0
7. 2 49/64
8. 2 47/64
9. 1.875
10. Upper 1.251
    Lower 1.249
11. 2 17/64
12. 3/64
13. 3/64
14. 60° 5'
15. under

Unit 17 DECIMAL DIMENSIONS AND DECIMAL TOLERANCES

DECIMAL DIMENSIONS

The decimal system of dimensioning is very widely used in industry because of the ease with which computations can be made, and the dimension can be measured with precision instruments to a high degree of accuracy.

The decimal system, as the name implies, makes use of decimal dimensions which can be read quickly and accurately in thousandths 1/1000" (.001"); ten thousandths 1/10,000 (.0001") and even finer divisions.

SPECIFYING DECIMAL TOLERANCES

Tolerances on decimal dimensions may be given on a drawing in a number of different ways. One of the common methods of specifying a tolerance that applies on all dimensions is to use a note such as:

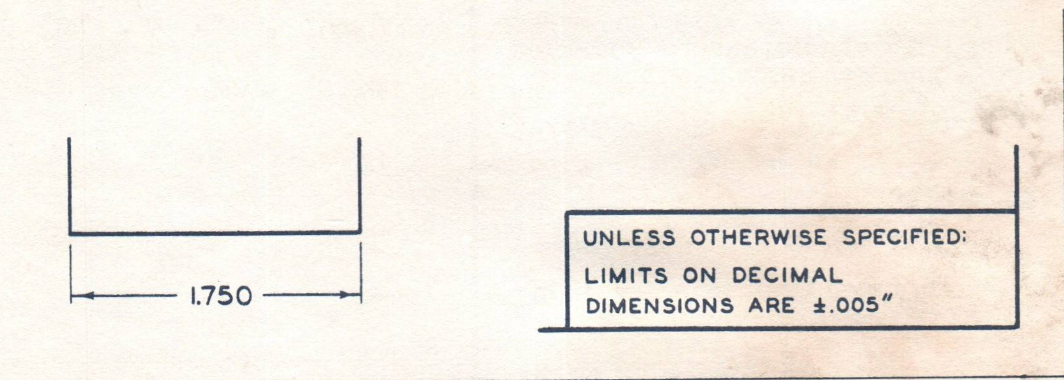


FIG. 64 DECIMAL TOLERANCES GIVEN IN A NOTE

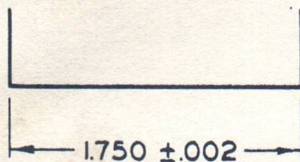
For example, the 1.750" dimension given on the drawing may be machined to a size between

1.750" + .005" = 1.755"

OR

1.750" − .005" = 1.745"

The larger size (1.755) is called the UPPER LIMIT. The smaller size (1.745) is referred to as the LOWER LIMIT. A tolerance on a decimal dimension may be included as part of the dimension, as illustrated in Figure 65.

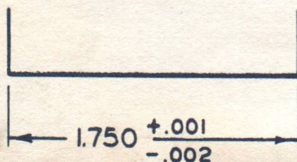


UPPER LIMIT 1.750" + .002" = 1.752"

LOWER LIMIT 1.750" - .002" = 1.748"

FIG. 65 DECIMAL TOLERANCE INCLUDED WITH DIMENSION

Where the plus and minus tolerance varies, as plus .001" and minus .002", the dimension may be shown as in Figure 66 on the drawing.

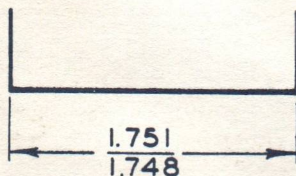


UPPER LIMIT 1.750" + .001" = 1.751"

LOWER LIMIT 1.750" - .002" = 1.748"

FIG. 66 VARIATION IN LIMITS

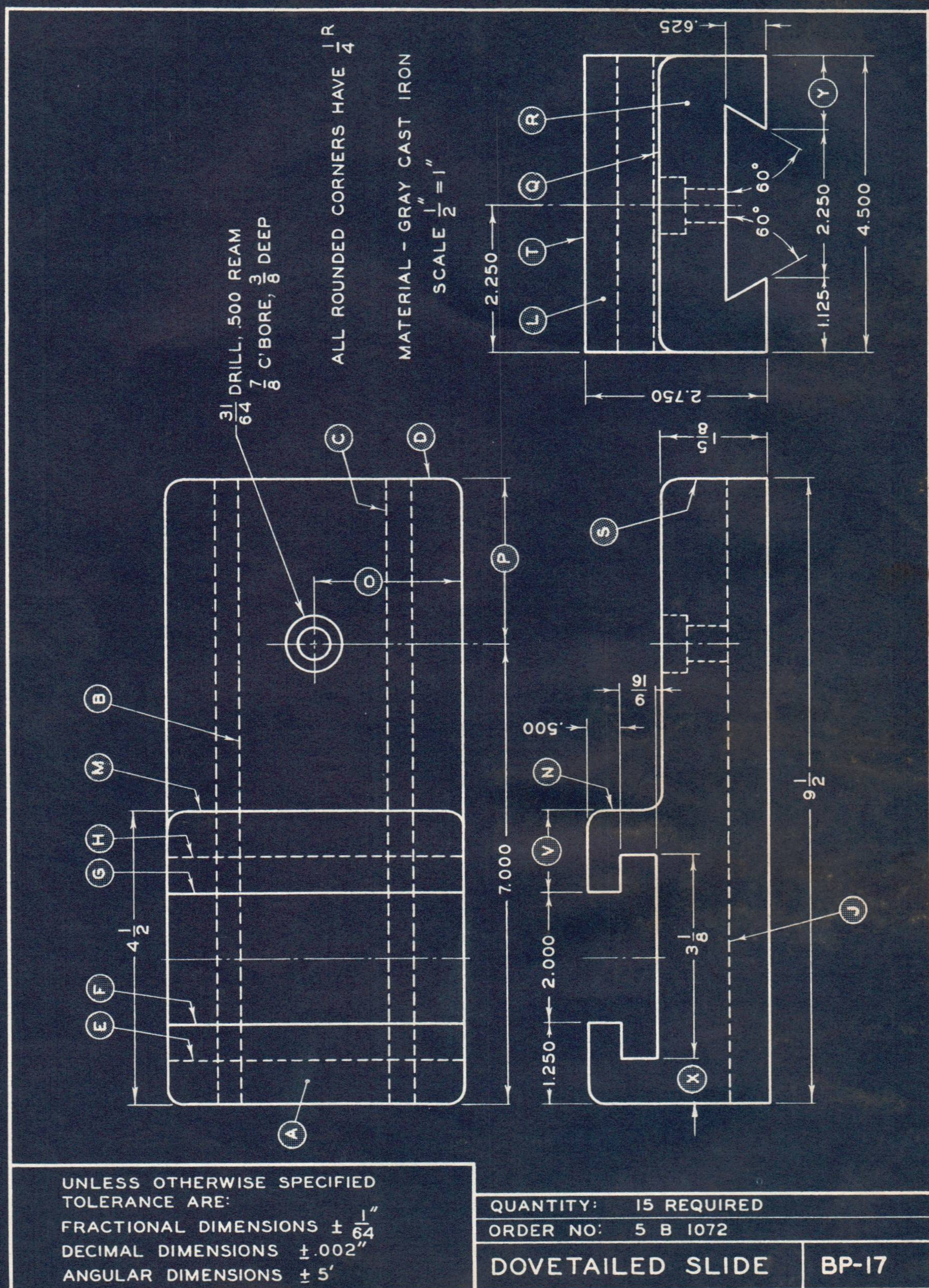
This same variation between the upper and lower limit can be given as in Figure 67. The dimension above the line is the upper limit; the dimension below the line, the lower limit.



UPPER LIMIT 1.751"

LOWER LIMIT 1.748"

FIG. 67 UPPER AND LOWER LIMIT DIMENSION



$\frac{31}{64}$ DRILL, .500 REAM
$\frac{7}{8}$ C'BORE, $\frac{3}{8}$ DEEP
ALL ROUNDED CORNERS HAVE $\frac{1}{4}$ R
MATERIAL - GRAY CAST IRON
SCALE $\frac{1}{2}'' = 1''$
.625
2.250
60° 60°
60°
2.250
4.500
1.125
2.750
7.000
$4\frac{1}{2}$
.500
2.000
1.250
$3\frac{1}{8}$
$9\frac{1}{2}$
UNLESS OTHERWISE SPECIFIED
TOLERANCE ARE:
FRACTIONAL DIMENSIONS $\pm \frac{1}{64}''$
DECIMAL DIMENSIONS $\pm .002''$
ANGULAR DIMENSIONS $\pm 5'$
QUANTITY: 15 REQUIRED
ORDER NO: 5 B 1072
DOVETAILED SLIDE
BP-17

DOVETAIL SLIDE (BP-17)

1. What type of lines are (B), (C), (H), (E) and (J) ?
2. What tolerance is allowed on
   a. Fractional dimensions
   b. Decimal dimensions
   c. Angular dimensions
3. What is the minimum overall height or thickness?
4. Give the upper limit dimension for the 60° angle.
5. Give the upper and lower limit dimension for (P).
6. What is the maximum depth to which the counterbored hole can be bored?
7. What line in the top view represents surface (R) of the side view?
8. What line in the front view represents surface (L) ?
9. What line in the side view represents surface (A) of the top view?
10. What dimension indicates how far line (J) is from the base of the slide?
11. What two lines in the top view indicate the opening of the dovetail?
12. How wide is the opening in the dovetail?
13. At what angle to the horizontal is the dovetail cut?
14. Give dimension (Y) .
15. To what depth into the piece is the dovetail cut?
16. What is the vertical distance from surface (Q) to surface (T) ?
17. What is the upper limit dimension between surfaces (F) and (G) ?
18. What is the full depth of the tee-slot?
19. Compute dimensions (V) and (X) .
20. What is the horizontal distance from line (N) to line (S) ?

Assignment Unit 17	Student's Name ________

1. hidden lines
2. a. 1/64"
   b. .002"
   c. 5'
3. 2.748
4. 59° 55'
5. upper 2 33/64
   lower 2 31/64
6. 60 5' 0"
7. D
8. N
9. T
10. .625
11. B C
12. 2.250
13. 60°
14. 1.125
15. .625
16. 1 1/8
17. 2.002
18. 1 1/16
19. V= 1.250 X= 1/16
20. ~~4 1/2~~ 5

Unit 18 REPRESENTING AND DIMENSIONING SCREW THREADS

Screw threads are widely used (1) to fasten two or more parts securely in position, (2) to transmit power and motion (such as a feed screw on a machine) and (3) to produce motion in an instrument in order to take precision measurements.

THE AMERICAN NATIONAL FORM THREAD

The shape of the most widely used thread form resembles a "V". The angle between the sides of the thread is 60°. The top and bottom of each thread is flat as shown in Figure 68.

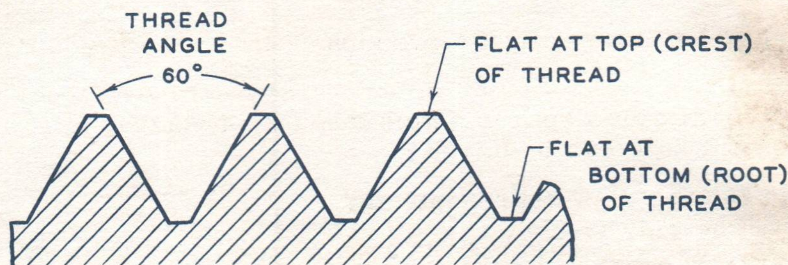


FIG. 68 CHARACTERISTICS OF THE AMERICAN NATIONAL FORM THREAD

Threads with this included angle were originally called "Sharp V" and later, "U. S. Standard". In 1928, the National Screw Thread Commission presented a report on the standardizing of screw threads. This commission adopted the term "National Form" to supersede the "U. S. Form". The findings of the National Screw Thread Commission were adopted in 1935 by the American Standards Association who, in turn, have continued to publish standardized data for American Standard Screw Threads.

The form of all American Standards Threads is specified as the American National Form. The symbol (NC) is used to denote a thread in the National Coarse Series, which superseded the old U. S. Standard Series. The finer thread series of the Society of Automotive Engineers (S.A.E.) and the American Society of Mechanical Engineers (A.S.M.E.), that included more threads per inch than the National Coarse Series, have been brought together in the National Fine (NF) Series.

REPRESENTING SCREW THREADS

Screw threads may be classified into two basic types: (1) external threads produced on the outside of a part and (2) internal threads cut on the inside. Both types of threads may be represented on a mechanical drawing by one of several different methods: (1) as they appear to the eye, (2) by conventional representation, and (3) by simplified representation. The accompanying chart (Fig. 69) shows how each type of thread is represented.

	(1) AS THEY APPEAR	(2) CONVENTIONAL REPRESENTATION	(3) SIMPLIFIED REPRESENTATION
EXTERNAL THREADS			
INTERNAL THREADS		(THREADED THROUGH)	

FIG. 69 REPRESENTATION OF SCREW THREADS

DIMENSIONING SCREW THREADS

The representation of each thread is accompanied by a series of dimensions, letters and numbers which, when combined, give full specifications for cutting and measuring the threads. The standard practices recommended by the American Standards Association (ASA) for specifying and dimensioning screw threads are illustrated in Figure 70.

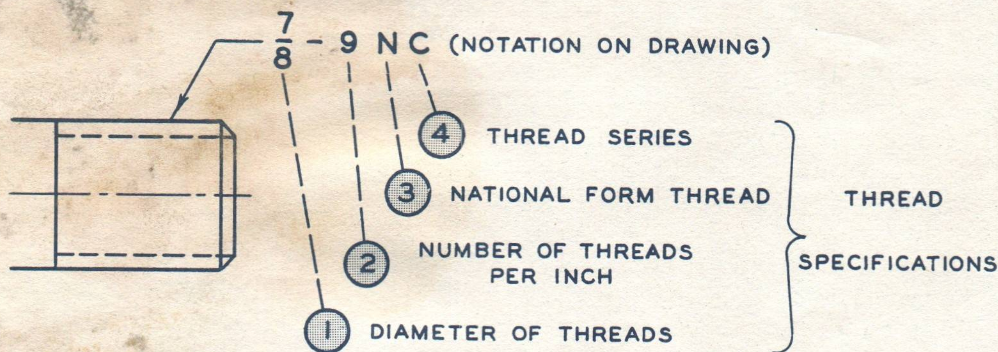
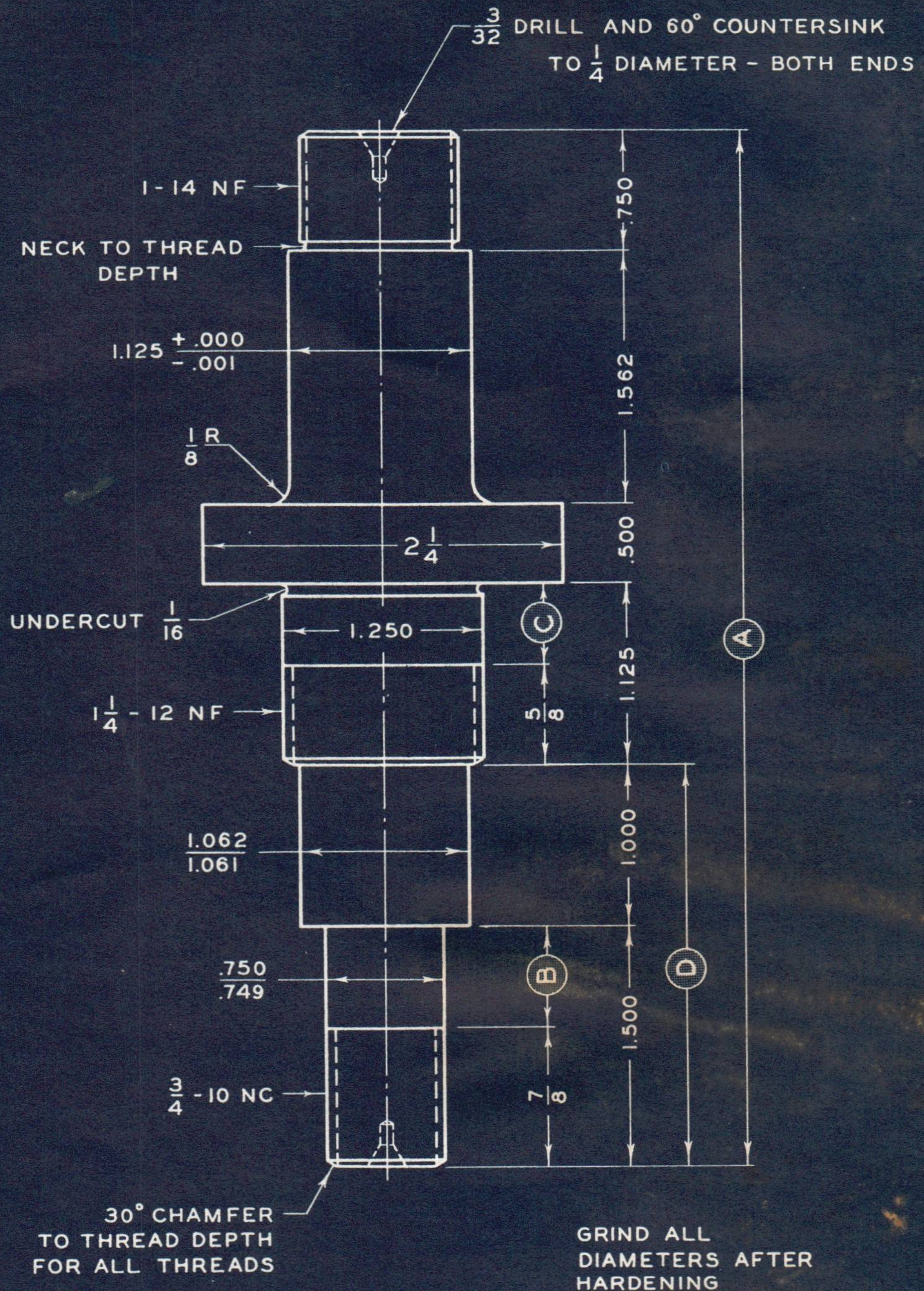


FIG. 70 SCREW THREAD DIMENSIONS

The diameter of the thread and the number of threads per inch are self-explanatory. The thread series for American National Screw Threads indicates that the thread is either National Coarse (NC), National Fine (NF) or one of the American Standard 8, 12 or 16 Pitch Series. Each of these series differs from one another only in the relationship of the number of threads per inch and the diameter of the part.

In this basic monograph, only the (NC), (NF) and the 8, 12, 16 Pitch Series will be included. Such other common thread shapes as the American National Acme, the Square Thread and Pipe Threads will be covered in an advanced volume.



UNLESS OTHERWISE SPECIFIED LIMITS ON DIMENSIONS ARE:
FRACTIONAL DIMENSIONS $\pm\frac{1}{64}''$
DECIMAL DIMENSIONS $\pm.002''$
ANGULAR DIMENSIONS $\pm 1°$

MAT'L. SAE 2335	
H. T. HARDEN AND TEMPER	
QUANTITY 42	
ORDER NO. L 224 - 1	
SPINDLE SHAFT	BP-18

SPINDLE SHAFT (BP-18)

1. What material is used for the part?
2. Give the overall length of the shaft.
3. What system of representation is used for the threaded portions?
4. At how many places are threads cut?
5. Start at the bottom of the part and give all the thread diameters.
6. Name the two thread series that the letters NC and NF specify.
7. How many threads per inch are to be cut on the 3/4", 1-1/4" and 1" diameters?
8. Give dimensions (B), (C) and (D).
9. Give the upper and lower limit dimensions for the 3/4" threaded portion.
10. What is the length of the 3/4" threads? The 1-1/4" threads?
11. Give the upper and lower limit dimensions of the 1-1/16" diameter portion.
12. What angle are the chamfers at the starting end of each thread cut?
13. What tolerance is specified for angular dimensions?
14. What is the upper and lower limit of size on the 1-1/8" diameter?
15. How long is that portion of the Shaft which has the 1-1/4"-12 thread?
16. Give the angle of the countersink.
17. What is the largest diameter that the 2-1/4" diameter can be machined to?
18. Give the diameter to which the center holes are countersunk.
19. How deep is the undercut on the 1-1/4" diameter?
20. Name the final machining operation for all diameters after the part is heat treated.

Assignment Unit 18	Student's Name ___________

1. SAE 2335
2. 6.437
3. simplified representation
4. 3
5. 3/4 D; 1 1/4 D; 1 D
6. N C national coarse; N F national fine
7. 3/4" 10 NC; 1-1/4" 12 NF; 1" 14 NF
8. (B) 5/8; (C) 1/2; (D) 2.500
9. Upper 4[illegible]/64; Lower 49/64
10. 3/4" 7/8; 1-1/4" 5/8
11. Upper 1.062; Lower 1.061
12. 30°
13. ±1°
14. Upper 1.125; Lower 1.124
15. 5/8
16. 60°
17. 2 17/64
18. 1/4 D
19. 1/16
20. grind

Unit 19 DIMENSIONING INTERNAL AND LEFT-HAND THREADS

DIMENSIONING THREADED HOLES

One of the most practical and widely used methods of producing internal threads is to cut them with a round formed thread-cutting tool. As this tool is turned and advances into the part, a groove is cut into the material the same shape and size as the threaded part with which it is to be fitted. This process, which is universally used on the smaller diameters, is called "tapping". The cutting tool is known as a "tap".

When a hole (which does not go through the part) is to be threaded, the drawing shows the drilled hole as a series of invisible lines which are pointed at the bottom to represent the drill point (Fig. 71). The illustration shows both the conventional and simplified method of representing a threaded hole.

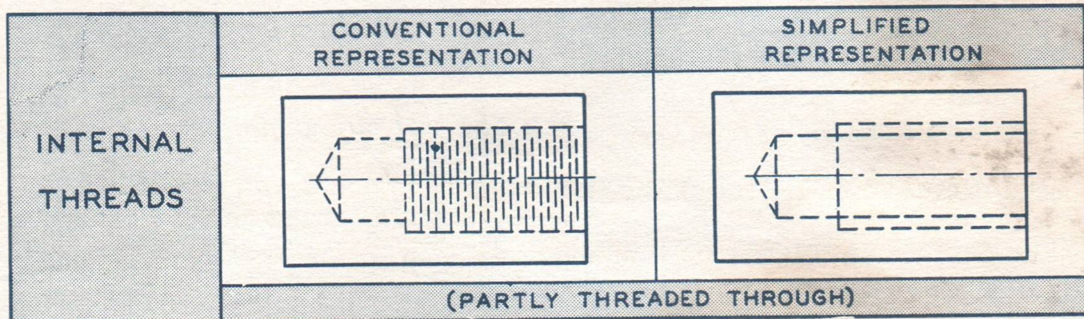


FIG. 71 REPRESENTATION OF TAPPED HOLES

Taps are comparatively inexpensive and are available at all times in the smaller sizes of the NC, NF and 8, 12 and 16 Pitch Series. The same system of dimensioning as is used for specifying external threads applies to internal threads. In addition, the depth of thread is included (Fig. 72).

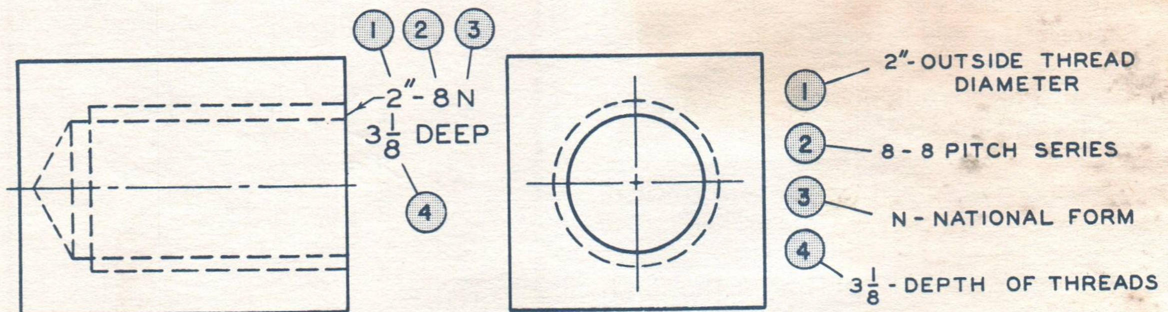


FIG. 72 DIMENSIONING A TAPPED HOLE

SPECIFYING THE FIT OF A THREAD

The degree of accuracy to which two mating threads must be machined is indicated on a drawing in terms of the "Class of Fit". The more accurately threads must fit together, the more expensive and time consuming they are to produce. To

provide for a wide range of variation in machining, a standard system of fits has been developed. In this system, four classes of fits ranging in number from 1 to 4 are widely used. The variation is from the loose Class 1 fit to the extremely accurate machined fit of Class 4.

DIMENSIONING LEFT-HAND THREADS

Screw threads are cut either right-hand or left-hand depending on the use required of the screw thread. As each name implies, a right-hand thread is advanced by turning clockwise ↻, or to the right; the left-hand thread, counter-clockwise ↺, or to the left.



FIG. 73 EXAMPLES OF RIGHT AND LEFT-HAND THREADS

For right-hand threads, no notation is made on the drawing as it is understood that this is the required type of thread. When a left-hand thread is required, the letters LH placed with the specifications denote "left-hand" (Fig. 74).

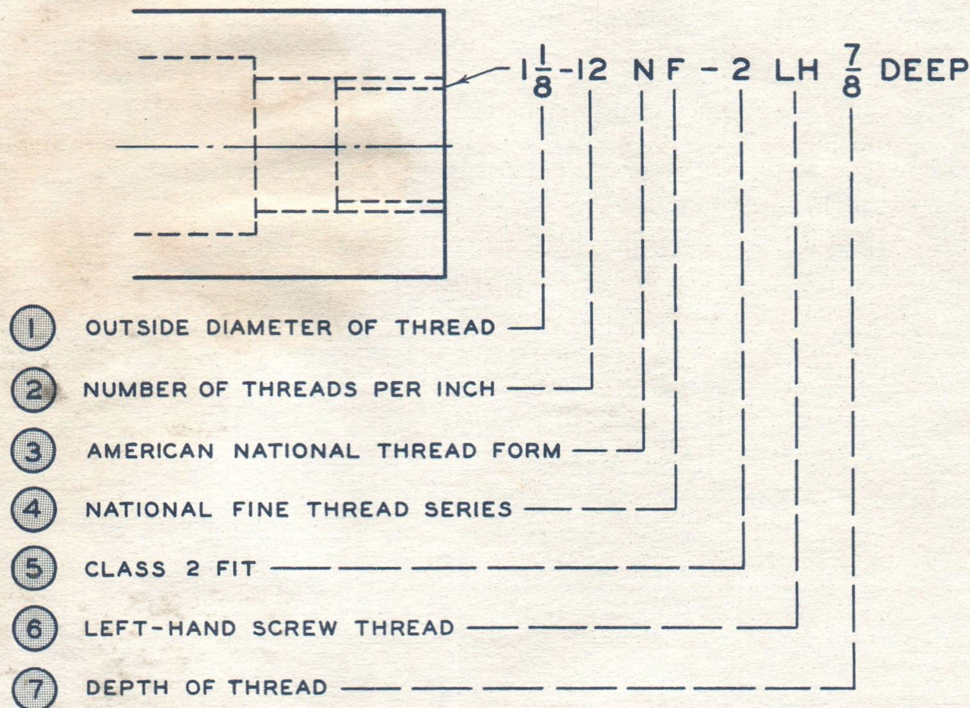
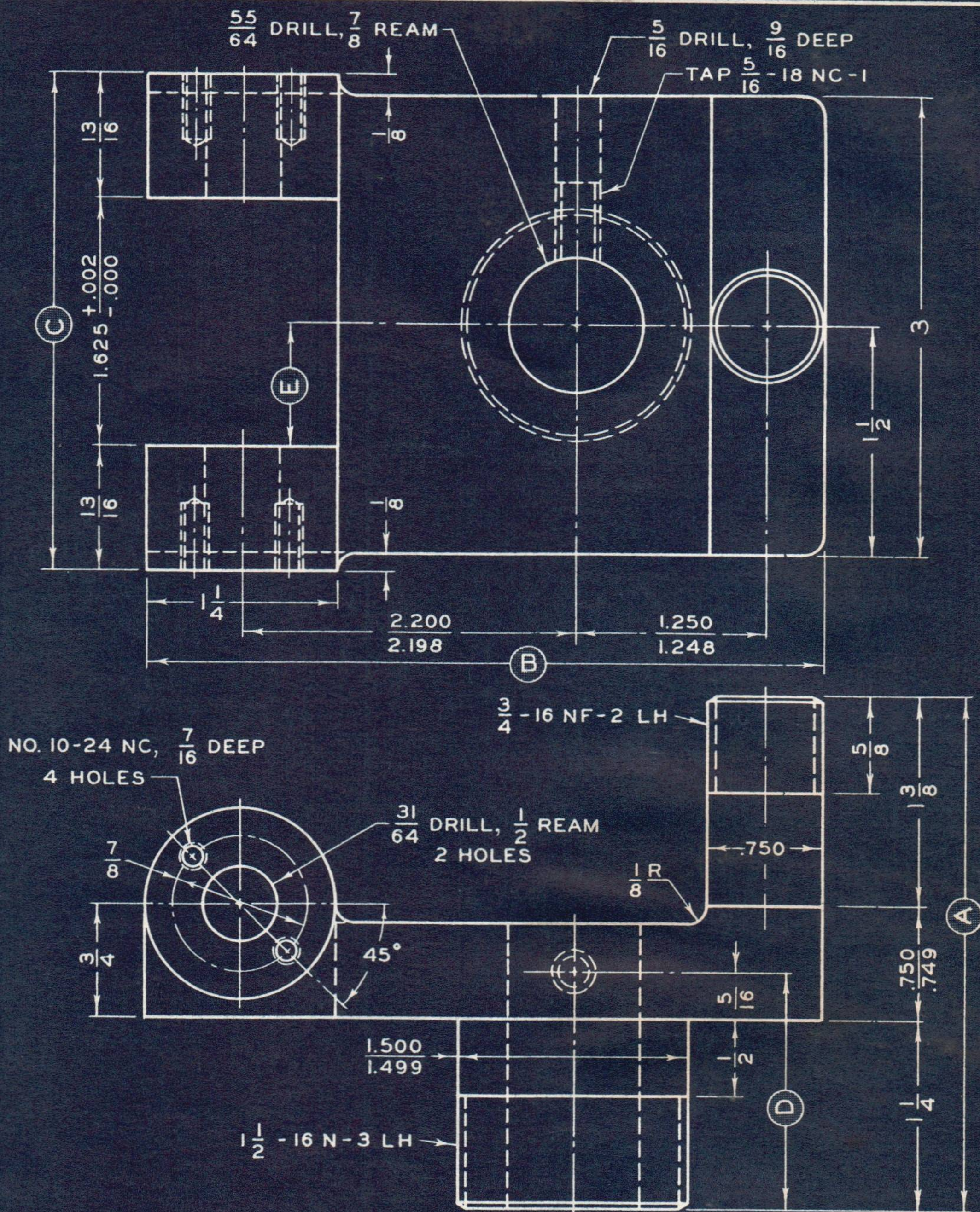


FIG. 74 MEANING OF THREAD SPECIFICATIONS



ALL FILLETS AND ROUNDS 1/8 R

UNLESS OTHERWISE SPECIFIED
LIMITS ON DIMENSIONS ARE:
FRACTIONAL DIMENSIONS ± 1/64″
DECIMAL DIMENSIONS ± .001
ANGULAR DIMENSIONS ± 15′

ORDER NO.	QTY.	MAT'L.	H.T.
9-H3	5	CAST STEEL	NORMALIZE AFTER ROUGH MACHINING

ROCKER BASE

DR. John Doe	CK. W.H. Pratt	BP-19
PART NO. Z-721	DATE 2-14-51	

ROCKER BASE (BP-19)

1. What material is specified?
2. What tolerances are allowed on:
   a. Decimal dimensions
   b. Fractional dimensions
   c. Angular dimensions
3. What heat treating process is required after rough machining?
4. Determine overall dimensions (A)(B)(C).
5. What is the radius of all fillets and rounds?
6. Compute dimensions (D) and (E).
7. How many holes are to be reamed 1/2"?
8. How many external threads are to be cut?
9. What thread series are used for the internal and external threads?
10. What does $\frac{3}{4}$ - 16NF - 2LH mean?
11. What are the upper and lower limits of the .750 diameter portion?
12. What does $1\frac{1}{2}$ - 16N - 2LH mean?
13. What does $\frac{5}{16}$ - 18NC - 1 mean?
14. What is the lower limit diameter of the unthreaded 1-1/2" diameter portion?
15. Determine the length of the 1-1/2"-16 threaded portion.
16. What diameter drill is used for the 7/8" reamed hole?
17. How many holes are to be threaded 10 - 24NC?
18. How deep are the holes to be threaded?
19. Give the angle to the horizontal at which the 10 - 24NC holes are to be drilled.
20. Give the diameter of the circle on which the 10 - 24NC tapped holes are located.

Assignment Unit 19

Student's Name ________

1. Cast iron
2. a. ±.001
   b. ± 1/64
   c. ± 15'
3. normalize
4. (A) 3 3/8
   (B) 4.450
   (C) 3.350
5. 1/8 R
6. (D) 1 7/8
   (E) 3/4
7. 2
8. 2
9. C + H
10. 3/4 diameter hole
    16 Per inch
    NF national fine
    2 fit   LH left hand
11. Upper .750   Lower .749
12. 1-1/2 diameter
    16 per inch
    N national
    2 fit   LH left hand
13. 5/16 diameter
    18 per inch
    NC national ~~coarse~~   1 fit
14. Lower Limit 1.499
15. 3/4
16. 55/64 D
17. 4
18. 7/16
19. 45°
20. 1 1/4

Unit 20 DIMENSIONING TAPERS AND MACHINED SURFACES

Blueprints of parts that uniformly change in size along their length show that the part is "tapered". On a round piece of work, the taper is the difference between the diameter at one point and a diameter farther along the length. The taper is usually specified by a note on the drawing which gives the TAPER PER FOOT or TAPER PER INCH. For example, a taper of one-half inch per foot is expressed:

$\frac{1}{2}$ TAPER PER FOOT

The drawing may give the large and small diameters at the beginning and end of the taper or one diameter and the length of the taper (Fig. 75).

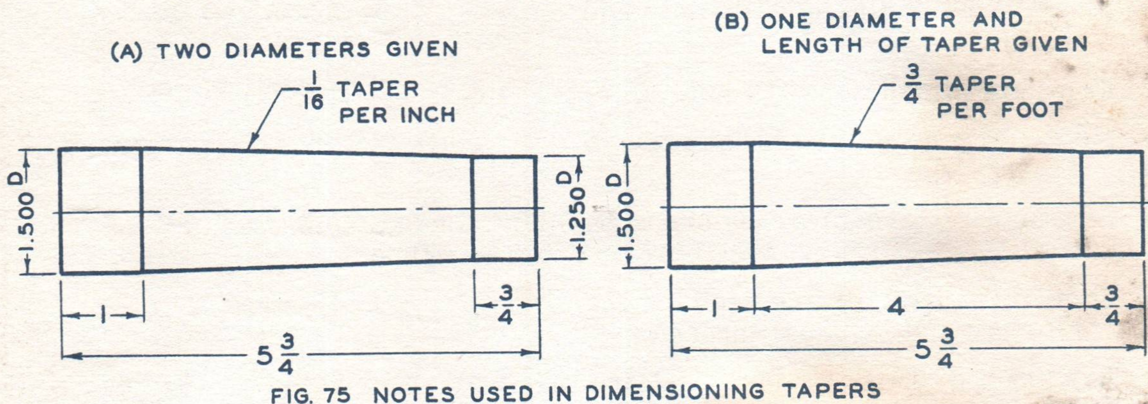


FIG. 75 NOTES USED IN DIMENSIONING TAPERS

FINISHED SURFACES

Surfaces that are machined to a smooth finish and to accurate dimensions are called "finished surfaces". A finish mark symbol such as a 60° 'V' on a drawing indicates that machining operations are to be performed on such surfaces of castings, forgings or welded parts.

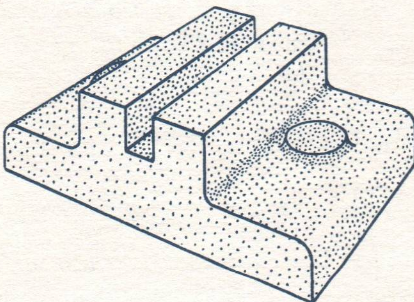


FIG. 76 ROUGH FORGING

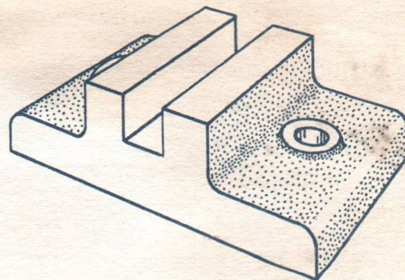


FIG. 77 MACHINED FORGING

The bottom of the 'V' touches the surface to be machined. Figure 76 shows a steel forging. This same forging as it looks when machined is illustrated in Figure 77. The working drawing (Fig. 78) shows how the finish marks are placed. Note that these marks appear on the hidden edge lines as well as on the object lines, with the exception of the small drilled holes. On large holes that require accurate machining, the 'V' is used once again.

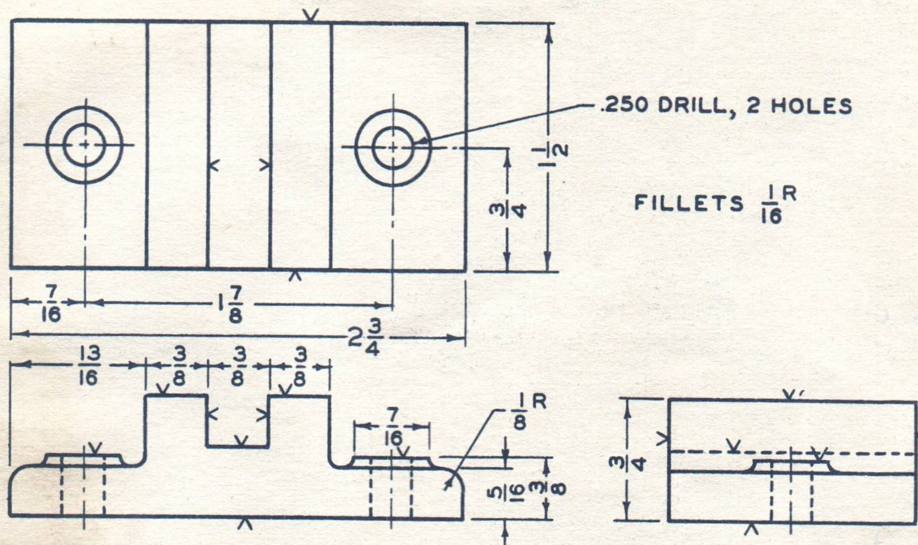


FIG. 78 WORKING DRAWING OF FORGING SHOWING APPLICATION OF FINISH MARKS

FINISH ALL OVER

When a casting, forging or welded part is to be finished all over, the drawing is simplified by omitting the finish marks and by adding the note: FINISH ALL OVER. The abbreviation F.A.O. means the same thing.

SURFACE FINISH

Letters, numbers and other symbols are used to indicate the machining operation to be performed on a surface or the degree of accuracy to which the machining must be held. These symbols, in many plants, appear in the opening of the 'V'. A few typical finish symbols are given in Figure 79.



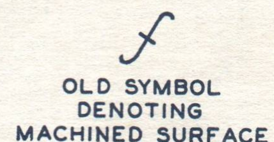
GRIND



MACHINED SMOOTH



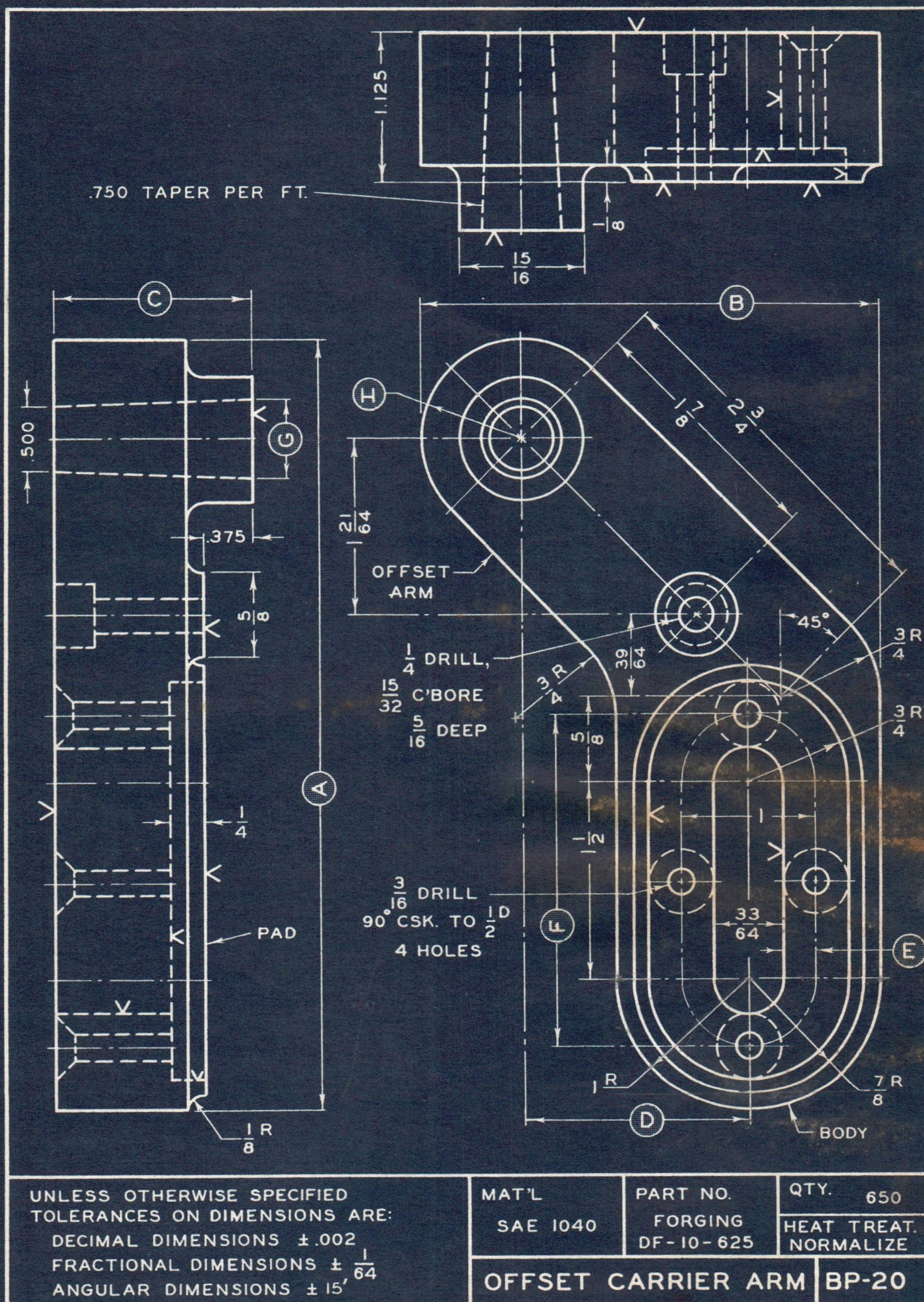
ROUGH MACHINED FINISH



OLD SYMBOL DENOTING MACHINED SURFACE

FIG. 79 EXAMPLES OF SURFACE FINISH SYMBOLS

In comparatively recent years there has been developed a more accurate system of denoting the higher degree of accuracy required in machining parts. These more precise standards for specifying quality of precision finished surfaces, as established by the American Standards Association and generally accepted throughout industry, will be covered in the advanced volume as more complex drawings and finer precision measurements are interpreted.


.750 TAPER PER FT.
1.125
15/16
1/8
C
B
H
.500
G
.375
5/8
1 7/8
2 3/4
1 21/64
OFFSET ARM
45°
3/4 R
1/4 DRILL,
15/32 C'BORE
5/16 DEEP
39/64
3/4 R
5/8
3/4 R
1/4
A
1 1/2
1
3/16 DRILL
90° CSK. TO 1/2 D
4 HOLES
33/64
PAD
F
E
1 R
7/8 R
1/8 R
D
BODY
UNLESS OTHERWISE SPECIFIED
TOLERANCES ON DIMENSIONS ARE:
DECIMAL DIMENSIONS ±.002
FRACTIONAL DIMENSIONS ± 1/64
ANGULAR DIMENSIONS ± 15'
MAT'L
SAE 1040
PART NO.
FORGING
DF-10-625
QTY. 650
HEAT TREAT.
NORMALIZE
OFFSET CARRIER ARM
BP-20

OFFSET CARRIER ARM (BP-20)

1. Name the three views.
2. What is the part number?
3. How many surfaces are to be machined?
4. Give the angle at which the arm is offset from the body.
5. What is the center to center distance of the offset arm?
6. Find the length of the elongated slot.
7. What is the overall length of the pad?
8. How is the counterbored hole specified?
9. What diameter drill is used for the countersunk holes?
10. What is the angle of the countersunk holes?
11. Compute the diameter at the large end of the tapered hole (G).
12. What tolerance is allowed on:
    a. Decimal dimensions
    b. Angular dimensions
    c. Fractional dimensions
13. What is the maximum overall height (A)?
14. Determine the minimum overall width (B).
15. Determine the maximum overall thickness (C).
16. What are dimensions (D) and (H)?
17. If the elongated slot is machined 1/2", would it be over, under, or within the specified limits?
18. What is the distance (E)?
19. Give center-to-center distance (F).
20. What heat treatment is required?

Assignment Unit 20	Student's Name ________

1. front V. ✓ left V top V ✓
2. DF-10-625
3. 13 ✓
4. 45°
5. 4.146 ✓
6. 2 1/4 ✓
7. 2 3/8 ✓
8. 1/4 drill 15/32 C'Bore 7/16 deep
9. 3/16 drill
10. 60° CSK ✓
11. (G) = .593 ✓
12. (a) ± .002
    (b) ± 15'
    (c) ± 1/64
13. (A) = 5 1/16 ✓
14. (B) = 3 27/64
15. (C) = 1.500 ✓
16. (D) = 1 1/16 (H) = 3/4 R
17. under ✓
18. (E) = 3/64 ✓
19. (F) = 2 ✓
20. normalize

Unit 21 DIMENSIONING WITH SHOP NOTES

The draftsman often resorts to the use of notes on a drawing in order to convey to the mechanic all the information needed to make a part. Notes such as those used for drilling, reaming, counterboring or countersinking holes are added to ordinary dimensions.

A note may consist of a very brief statement at the end of a leader or the note may be a complete sentence which gives an adequate picture of machining processes and all necessary dimensions. A note is found on a drawing near the part to which it refers. This unit includes machining notes which are found on drawings of knurled surfaces, chamfers, grooves and keyways. A sample of a typical change note is also given.

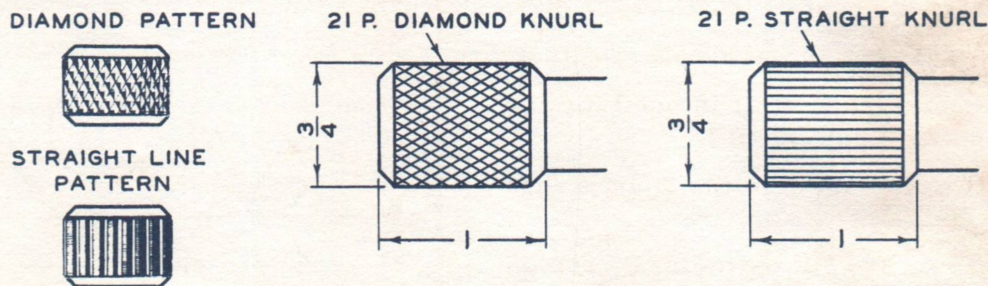


FIG. 80 DIMENSIONS AND NOTES FOR KNURLED SURFACES

DIMENSIONING KNURLED SURFACES

The term "knurl" refers to a raised diamond shaped surface or straight line impression in the surface of a part (Fig. 80). The dimensions and notes which furnish sufficient information for the craftsman to produce the knurled part are shown in this same figure. The pitch of the knurl, which gives the number of teeth per linear inch, is the size. The standard pitches are: coarse (14P), medium (21P) and fine (33P).

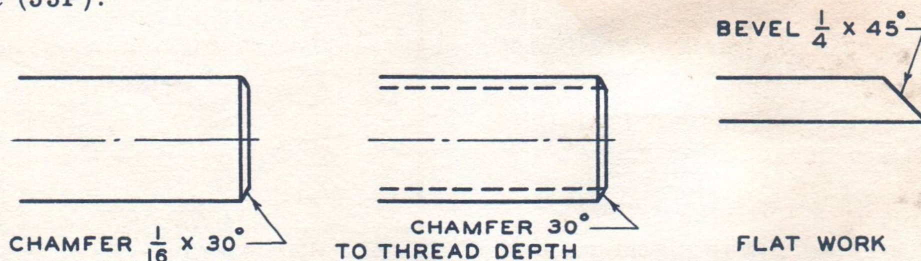


FIG. 81 DIMENSIONING CHAMFERS AND BEVELS

DIMENSIONING CHAMFERS AND GROOVES

Where a surface must be cut away at a slight bevel, or have a groove cut into it, the drawing or blueprint gives complete machining information in the form illustrated in Figures 81 and 82.

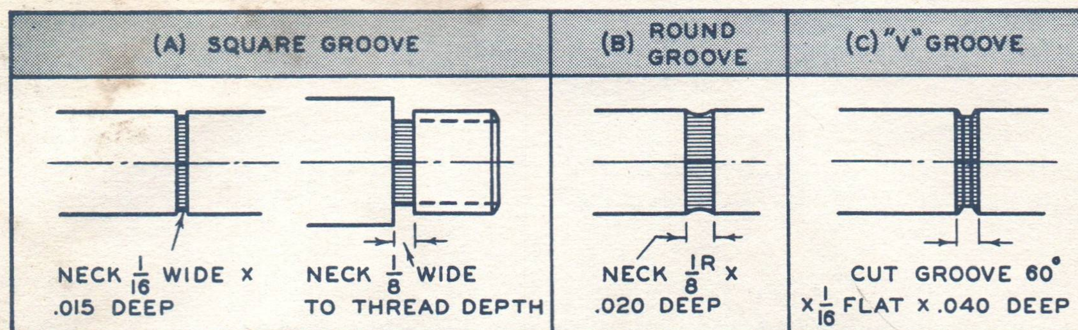


FIG. 82 DIMENSIONING THREE COMMON TYPES OF GROOVES

KEYWAYS

A keyway refers to a groove cut into a shaft and a mating part. In this keyway, a key is placed to keep both parts in a fixed position and to prevent either part from turning.

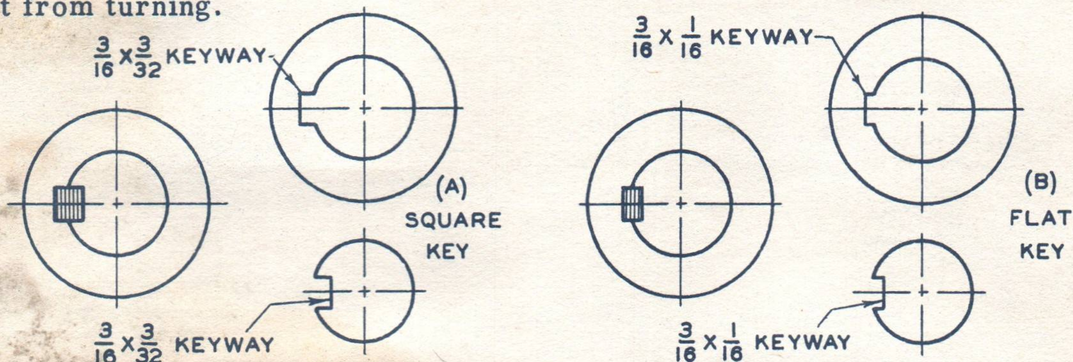


FIG. 83 DIMENSIONING SQUARE AND FLAT KEYWAYS

Keyways for square and flat keys are dimensioned with the width of the keyway given first, followed by the depth. The method of dimensioning for square and flat keys is shown in Figure 83.

CHANGE NOTES

The specifications and dimensions of parts are frequently changed on working drawings. An accurate record is usually made on the tracing and blueprint to indicate the nature of the change, the date and who made the changes.

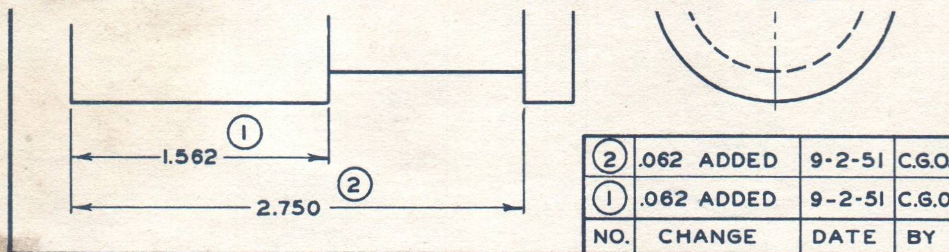
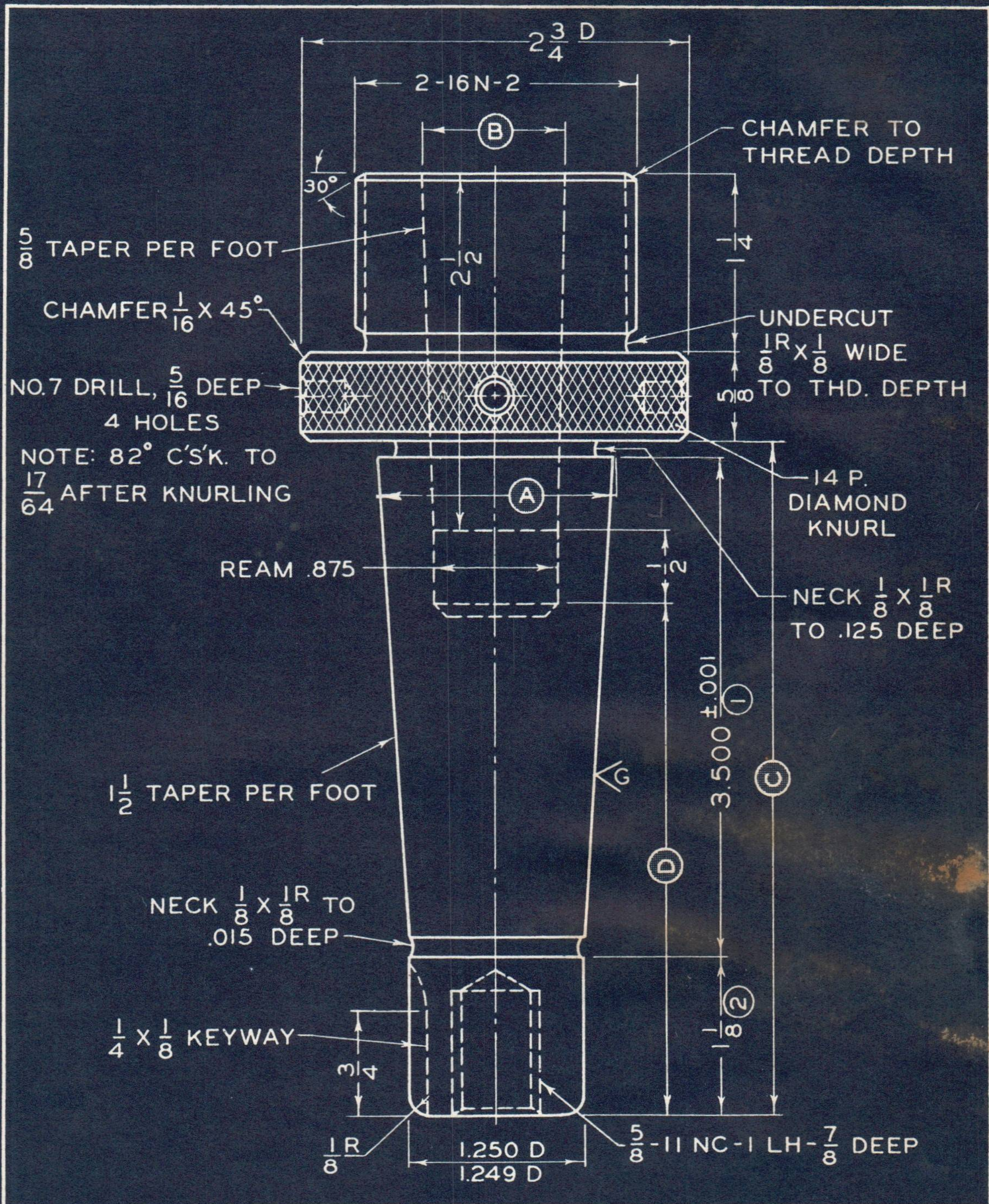


FIG. 84 APPLICATION OF CHANGE NOTES

Changes that are minor in nature may be made without altering the original lines on the drawing. One of the easiest ways of making such changes is shown in Figure 84.



NO.	CHANGE	DATE	BY
2	WAS 1.125	9-5-51	T.P.O.
1	.125 ADDED	9-5-51	T.P.O.

UNLESS OTHERWISE SPECIFIED TOLERANCES ON DIMEMSIONS ARE:
DECIMAL DIMENSIONS ±.002
FRACTIONAL DIMENSIONS ± 1/64
ANGULAR DIMENSIONS ± 1°

CUTTER ADAPTER BP-21

CUTTER ADAPTER (BP-21)

1. What tolerances are given for:
   a. Angular dimensions
   b. Decimal dimensions
   c. Fractional dimensions
2. Give the exact specifications for the taper on the body.
3. What is the taper per inch for the body?
4. What is the diameter at the small end of the outside taper?
5. Determine dimension (A).
6. Give the taper for the hole.
7. What is the taper per inch for the hole?
8. Give the diameter at the small end of the inside taper.
9. Compute dimension (B).
10. Give the specifications for the outside threads on the nose portion.
11. What does the LH in the thread note for the shank end specify?
12. What is the class of fit for the 2" threaded nose?
13. What operation is performed on the 2-3/4" diameter?
14. How is this operation specified?
15. Determine the maximum diameter for the reamed hole.
16. Give the note for drilling the four holes in the largest diameter?
17. Specify the chamfer for the knurled portion.
18. Specify the angle of chamfer for the 2" threaded nose.
19. How deep is the chamfer for the 2" threads?
20. Give the original length of the tapered body before any change was made.

Assignment Unit 21	Student's Name ________

1. Angular ±1°
   Decimal ±.002
   Fractional ± 1/64
2. 1/2 taper per ft
3. 1/8
4. 1.250 D
5. 1.687
6. 5/8 per ft
7. .052
8. .875
9. 1.005
10. 2-16N-2
11. left hand
12. 2
13. Knurl
14. 14 P Diamond Knurl
15. .875
16. No. 7 DRILL 5/16 DEEP 4 holes
17. Chamfer 1/16 × 45°
18. 30°
19. Deep 1/8
    Angle 30°
20. 3.325
21. 4 7/8
22. grind
23. 3 3/4
24. Width 1/4
    Depth 1/8
25. 6 3/4

21. Compute maximum length of dimension (C).
22. What machining operation is indicated by the finish symbol G ?
23. Determine dimension (D).
24. Give the dimensions of the keyway.
25. Determine the overall length.

Unit 22 CUTTING PLANES, SECTION LINING AND FULL SECTIONS

An exterior view shows the object as it looks when seen from the outside. The inside details of such an object are shown on the drawing by hidden lines.

As the details inside the part become more complex, and more and more invisible lines are needed to show the hidden details accurately, the drawing becomes increasingly more difficult to interpret. One technique the draftsman uses on such drawings to simplify them is to cut away a portion of the object and expose the inside surfaces. On such cut-away sections, all of the edges that are visible are represented by visible edge or object lines.

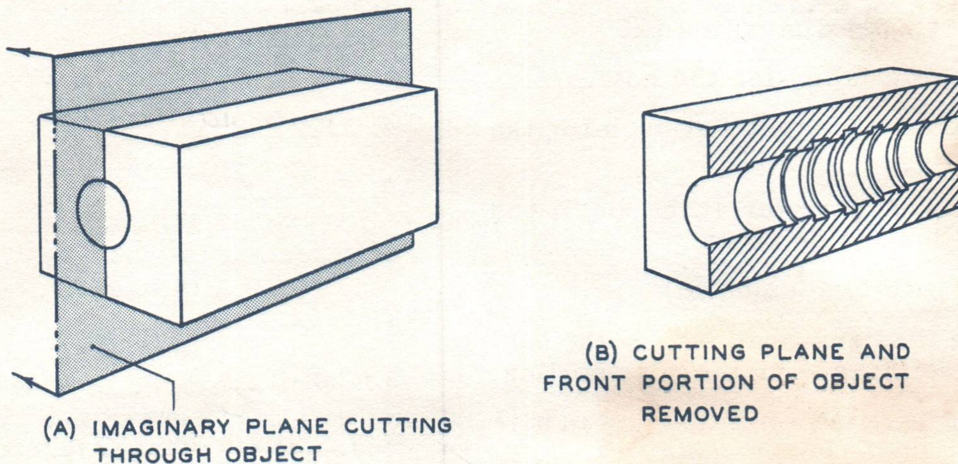


FIG. 85 CUTTING PLANE AND ITS APPLICATION

To get this sectional view, an imaginary cutting plane is passed through the object as shown in Figure 85 at (A) and a portion is removed as at (B). The direction and surface through which the cutting plane passes is very simply represented on the drawing by a cutting plane line. The exposed surfaces, which have been cut through, are further identified by a number of slant lines called "section" or "crosshatch" lines. Where the cutting plane passes completely through the object, the sectional view is called a "full section".

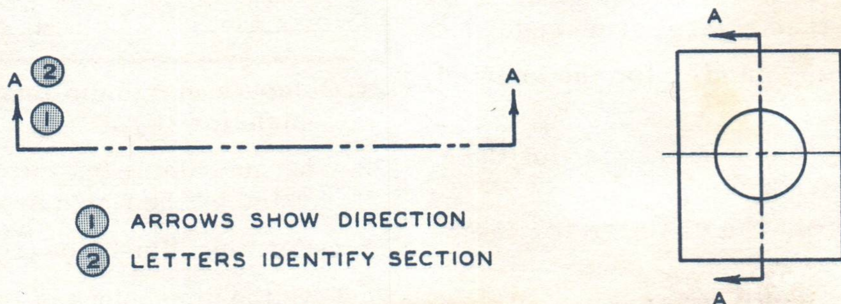


FIG. 86 THE CUTTING PLANE LINE

CUTTING PLANE LINES

The cutting plane line is a heavy line with one long and two short dashes as shown in Figure 86. The line represents the edge of the cutting plane. The arrowheads on the ends of the cutting plane line show the direction in which the section is viewed. A letter is usually placed near each arrowhead to identify the section.

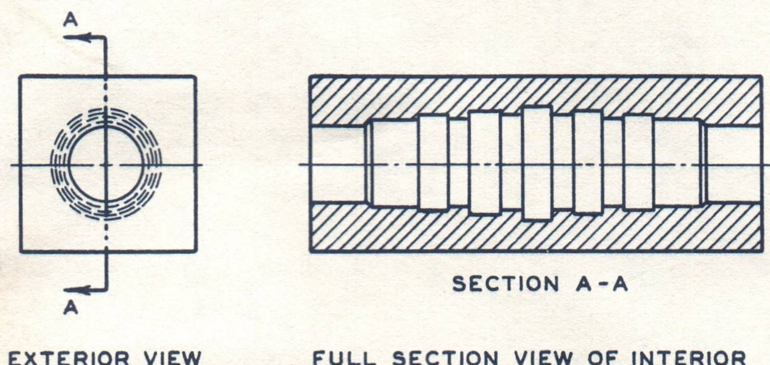


FIG. 87 SECTION VIEWS SIMPLIFY INTERNAL DETAILS

CROSS-HATCHING OR SECTION LINING

The interpretation of a sectional drawing is further simplified by cross-hatch or section lines (Fig. 87). It is easy to identify one part from another on a cut-away section, where section lines are used, because each combination of lightly drawn slant lines refers to a different material. The cross-hatch line combinations are largely standardized and universally used so that they constantly refer to the same materials (Fig. 88).

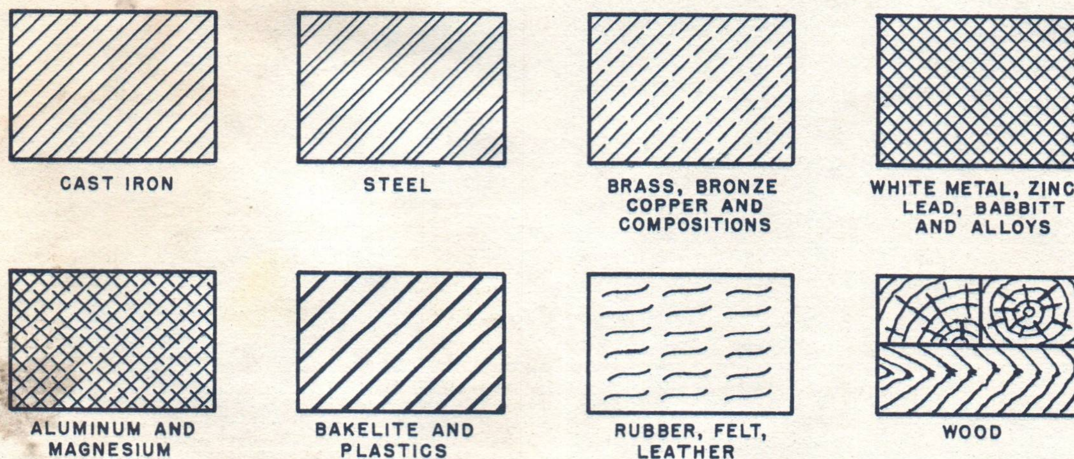
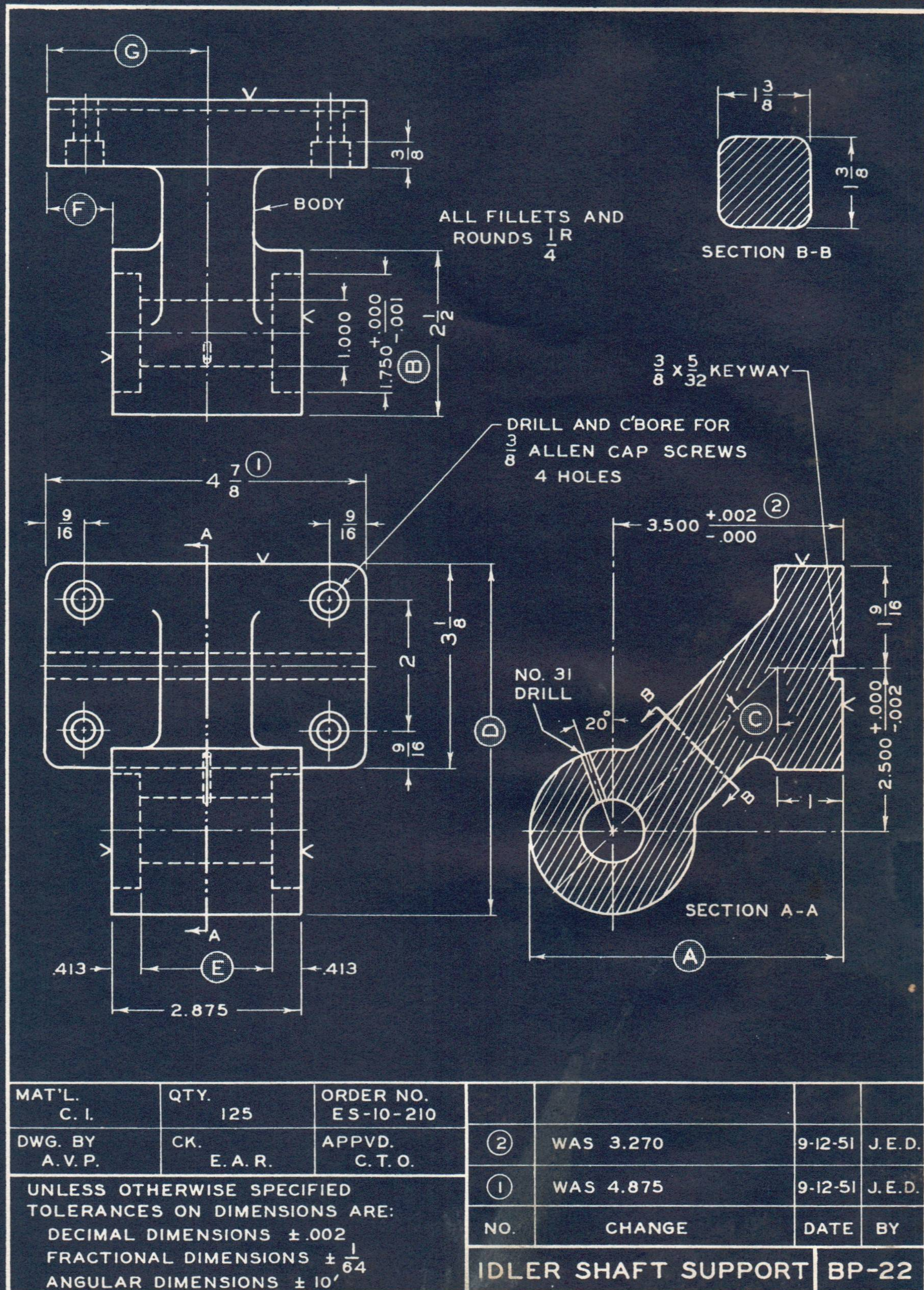


FIG. 88 SECTION LININGS IDENTIFY MATERIALS


G
F
BODY
ALL FILLETS AND ROUNDS 1/4 R
SECTION B-B
1 3/8
3/8 X 5/32 KEYWAY
DRILL AND C'BORE FOR 3/8 ALLEN CAP SCREWS 4 HOLES
1.000
1.750 +.000 -.001
B
2 1/2
4 7/8
9/16
A
3 1/8
2
D
NO. 31 DRILL
20°
3.500 +.002 -.000
C
1 9/16
2.500 +.000 -.002
1
SECTION A-A
.413
E
2.875
MAT'L. C. I.
QTY. 125
ORDER NO. ES-10-210
DWG. BY A.V.P.
CK. E.A.R.
APPVD. C.T.O.
UNLESS OTHERWISE SPECIFIED TOLERANCES ON DIMENSIONS ARE:
DECIMAL DIMENSIONS ±.002
FRACTIONAL DIMENSIONS ± 1/64
ANGULAR DIMENSIONS ± 10'
2 WAS 3.270 9-12-51 J.E.D.
1 WAS 4.875 9-12-51 J.E.D.
NO. CHANGE DATE BY
IDLER SHAFT SUPPORT
BP-22

IDLER SHAFT SUPPORT (BP-22)

1. Give the specifications for the counterbored holes.
2. How deep are the counterbored holes?
3. Give the specifications for the flat keyway.
4. What size are the fillets and rounds?
5. What size drill is used for the hole drilled at an angle?
6. Give the tolerance on the 20° dimension.
7. Compute angle (C) from dimensions given on drawing.
8. Give the maximum diameter for the 1" hole.
9. What is the largest size to which diameter (B) can be bored?
10. How are the machined surfaces indicated?
11. What type line shows where Section A-A is taken? In what view?
12. Determine dimensions (A) and (D).
13. Determine from Section B-B what material is required.
14. How wide and thick is the body?
15. Indicate what two changes were made from the original drawing.
16. Determine minimum dimension (E).
17. Compute maximum dimension (F).
18. What is upper limit dimension (G)?
19. Why is section A-A a full section?
20. Show the section linings for aluminum and for steel.

Assignment Unit 22	Student's Name ___________

1. Drill and C'Bore for 3/8 allen cap screws 4 holes
2. 3/8
3. 3/8 x 5/32
4. 1/4 R
5. no. 31
6. ± 10'
7. Angle (C) = 45°
8. 1.002
9. 1.750
10. V
11. Cutting plane front V
12. (A) = 1 3/4 (D) = 5. 5/16
13. cast iron
14. 1 3/4 x 1 3/8
15. 3.500 was 3.270; 4 7/8 was 4.875
16. (E) = 1.947 ✓
17. (F) = 1.951 ✓
18. (G) = 2.439 ✓
19. Because of the plane lines
20. Aluminum Steel

Unit 23 HALF SECTIONS, PARTIAL SECTIONS AND CONVENTIONAL BREAKS

HALF SECTIONS

The internal and external details of a part may be clearly represented by a sectional view called a "half section". In a half section view, one half of the object is drawn in section and the other half as an exterior view (Fig. 89). The half section is used principally where both the inside and outside details are symmetrical and where a full section would omit some important detail in an exterior view.

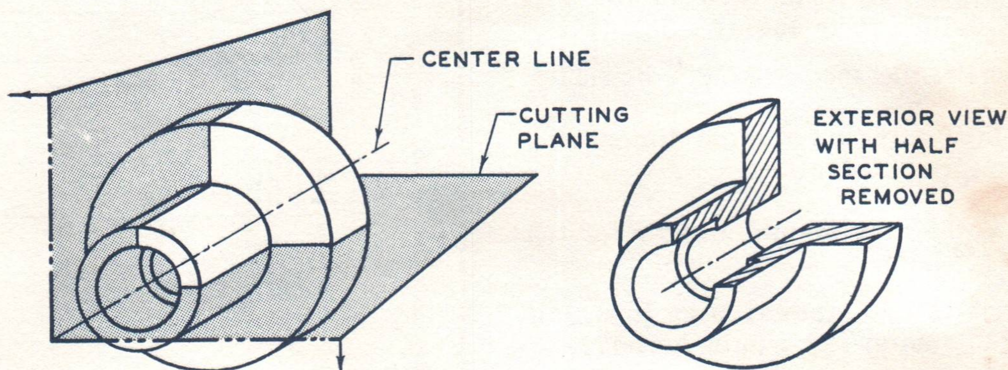


FIG. 89 HALF SECTION VIEW

Theoretically, the cutting plane for a half section view extends halfway through the object, stopping at the axis or center line (Fig. 90). Drawings of simple symmetrical parts may not always include the cutting plane line, arrows and letters showing the direction in which the section is taken. Also, hidden lines are not shown in the sectional view unless they are needed to give details of construction or for dimensioning.

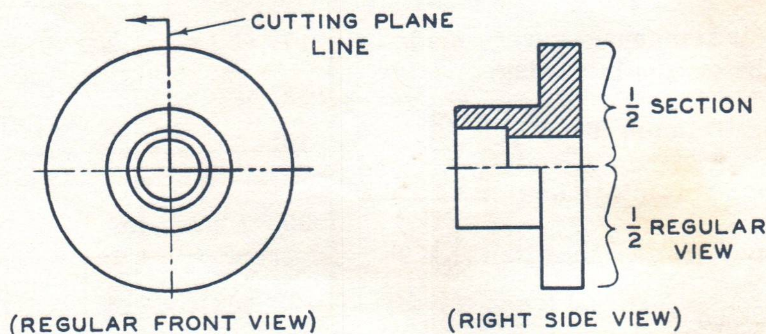


FIG. 90 CUTTING PLANE LINE AND HALF SECTION VIEW

BROKEN OR PARTIAL SECTIONS

On some parts neither a full nor a half section is needed to expose the interior details. In such cases, a "broken-out" or "partial section" may be used (Fig. 91). A cutting plane is imagined being passed through a portion of the object and the part in front of it broken away. The break line is an irregular freehand line which separates the internal sectioned view and the external view.

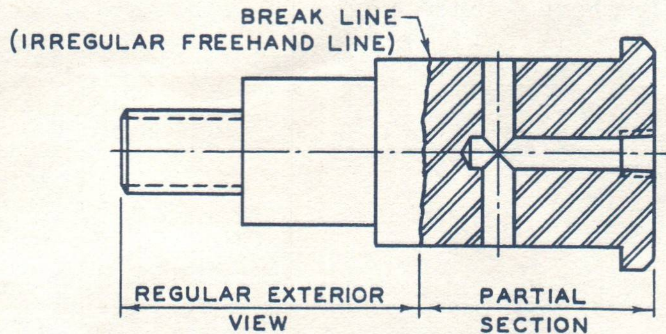


FIG. 91 EXAMPLE OF BROKEN-OUT OR PARTIAL SECTION

CONVENTIONAL BREAKS

A long part with a uniform cross section may be drawn to fit on a standard size drawing sheet by cutting out a portion of the length. In this manner, a part may be drawn larger to bring out some complicated details.

The cut away portion may be represented by a conventional symbol which does two things: (1) indicates that a portion of uniform cross section is removed and (2) shows the internal shape. A few conventional symbols which are accepted as standard are illustrated in Figure 92.

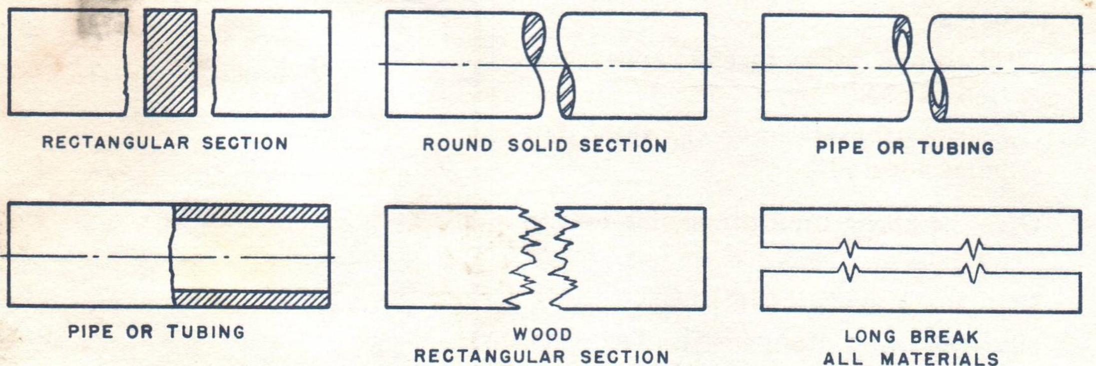
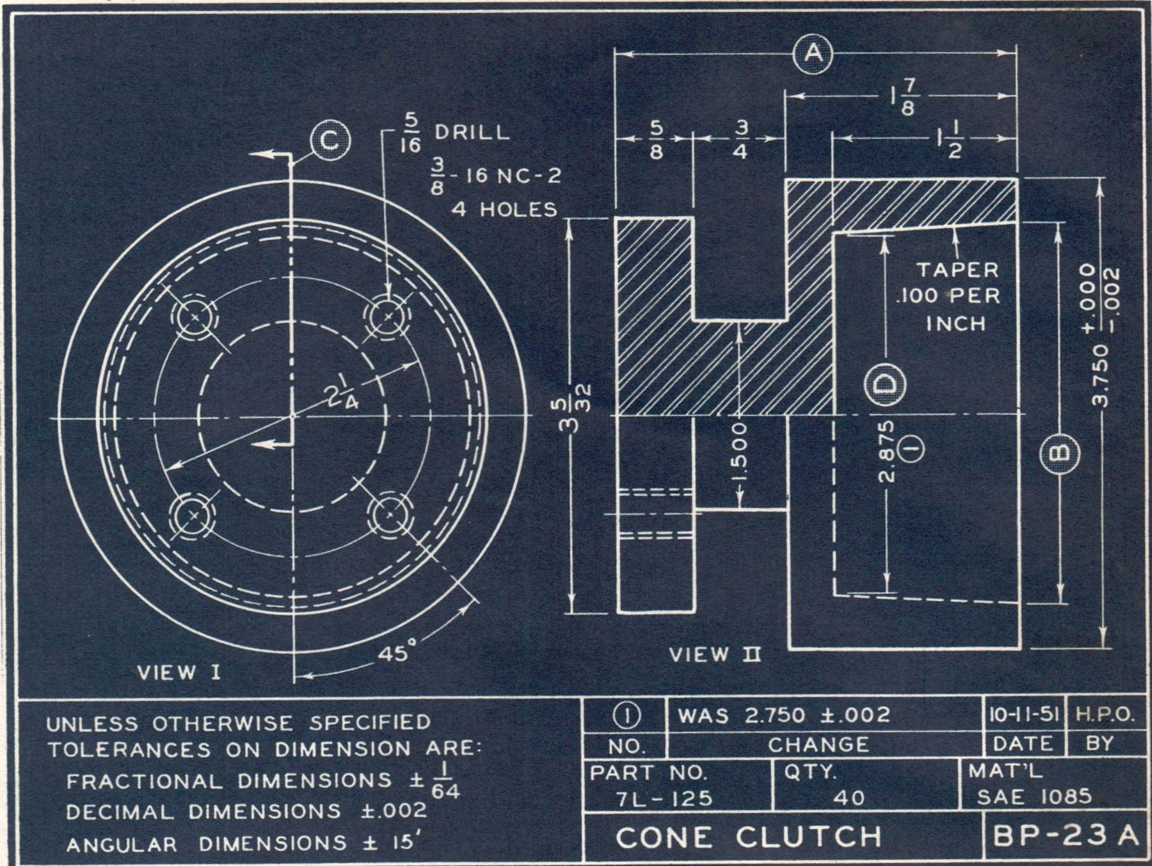


FIG. 92 STANDARD BREAK SYMBOLS

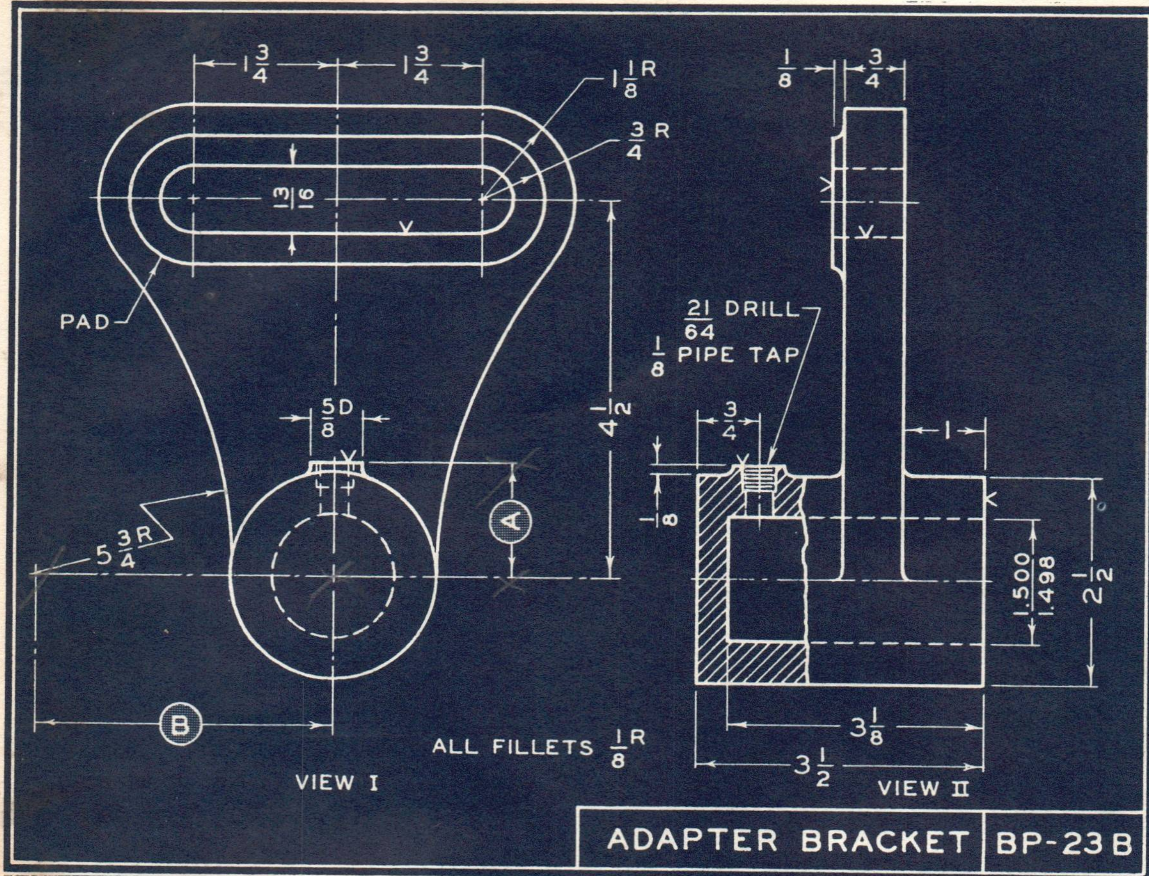


CONE CLUTCH (BP-23A)

1. Name View I and View II.
2. What type line is (C)?
3. Give the specifications for the tapped holes.
4. What type of screw thread representation is used?
5. On what diameter are the threaded holes located?
6. Give the upper limit dimension for the 45° angle.
7. Determine overall width (A).
8. Give the lower limit for the 1.500" D.
9. Compute dimension (B).
10. Give the original diameter of (D).

Assignment Unit 23A	Student's Name __________

1. View I ~~top~~ ✓ ✓
   View II R. side ✓
2. (C) cutting plane line
3. ✓ taper .100 per inch
4. 16 NC-2 ✓
5. 2 1/4 D 6. 45° 15' 0"
7. (A) = 3 1/4 8. 1.498 D
9. (B) = 3.025 10. (D) = 2.750 D



ADAPTER BRACKET (BP-23B)

1. Name View I and View II.
2. How many outside machined surfaces are indicated in View II?
3. Give the upper and lower limits of the bored hole.
4. How deep is the hole bored?
5. What is the drill size for the tapped hole?
6. What size pipe tap is used?
7. Give the center to center distance of the elongated slot.
8. Compute dimension (A).
9. Determine overall length of pad.
10. Compute dimension (B).

Assignment Unit 23B	Student's Name ________

1. View I front V.
   View II R. side V.
2. 3
3. Upper 1.500   4. 3/4
   Lower 1.498   5. 3/64
6. 1/8 pipe tap   7. 3 1/2
8. (A) = 1 3/4   9. 4 1/4 ✓5
10. (B) = 7

Shop Sketching



PART TWO

Unit 24 SKETCHING HORIZONTAL, VERTICAL AND SLANT LINES

THE VALUE OF SKETCHING

Many parts or assembled units may be described clearly and adequately by one or more freehand sketches. Sketching is another way of conveying ideas rather than a method for making completed drawings perfectly.

The craftsman, therefore, in addition to being able to interpret drawings and blueprints accurately and easily is called upon to make sketches. By sketching additional views not found on blueprints, the mechanic often studies the part thoroughly and is able to understand the processes required to fabricate or machine it. Sketches may be made conveniently at any time or place as the only tools needed are a soft pencil and any available paper.

SKETCHING LINES FREEHAND

The development of correct skills in sketching lines freehand is more essential for the beginner than speed. After the basic principles of sketching have been learned and skill has been acquired in making neat and accurate sketches, then stress should be placed on speed.

Although shop sketches are made on the job and no special pencil needs to be used, a soft lead pencil with a cone shaped point will produce best results. For fine lines, use a fairly sharp point; for heavier lines, round the point more (Fig. 93).



FIG. 93 SHARPNESS OF PENCIL POINT INFLUENCES LINE WEIGHT

SKETCHING HORIZONTAL LINES

The same principles of drafting which apply to the making of a mechanical drawing and the interpretation of blueprints are used for making sketches.

In sketching, the pencil is held 3/4" to 1" from the point so the lines to be drawn may be seen easily and there is a free and easy movement of the pencil. A free arm movement makes it possible to sketch smooth, neat lines as compared with the rough and inaccurate lines produced by a finger and wrist movement.

In planning the first horizontal line on a sketch, place two points on the paper to mark the beginning and end of the line (Fig. 94 at A). Place the pencil point on the first dot. Then, with a free arm movement and with the eyes focused on the right point, draw the line from left to right (Fig. 94 at B).



(A)
POINTS PLACED AT
ENDS OF LINE

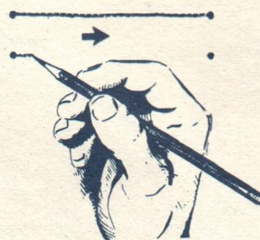


FIG. 94 SKETCHING HORIZONTAL LINES

Examine the line for straightness, smoothness and weight. If too light, a softer pencil or a more rounded point may be needed. On long lines, extra dots are often placed between the start and finish points of the line. These intermediate dots are used as a guide for drawing straight lines.

SKETCHING VERTICAL LINES

The same techniques for holding the pencil and using a free arm movement apply in sketching vertical lines. Dots may again be used to indicate the beginning and end of the vertical line. Start the line from the top and move the pencil downward as shown in Figure 95. For long lines, if possible, the paper may be turned to a convenient position.

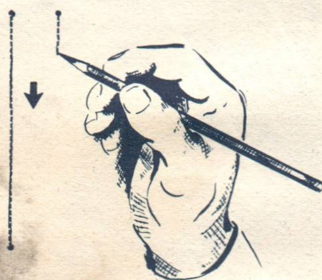


FIG. 95
SKETCHING VERTICAL LINES

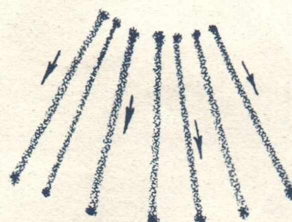


FIG. 96
SKETCHING SLANT LINES

SKETCHING SLANT LINES

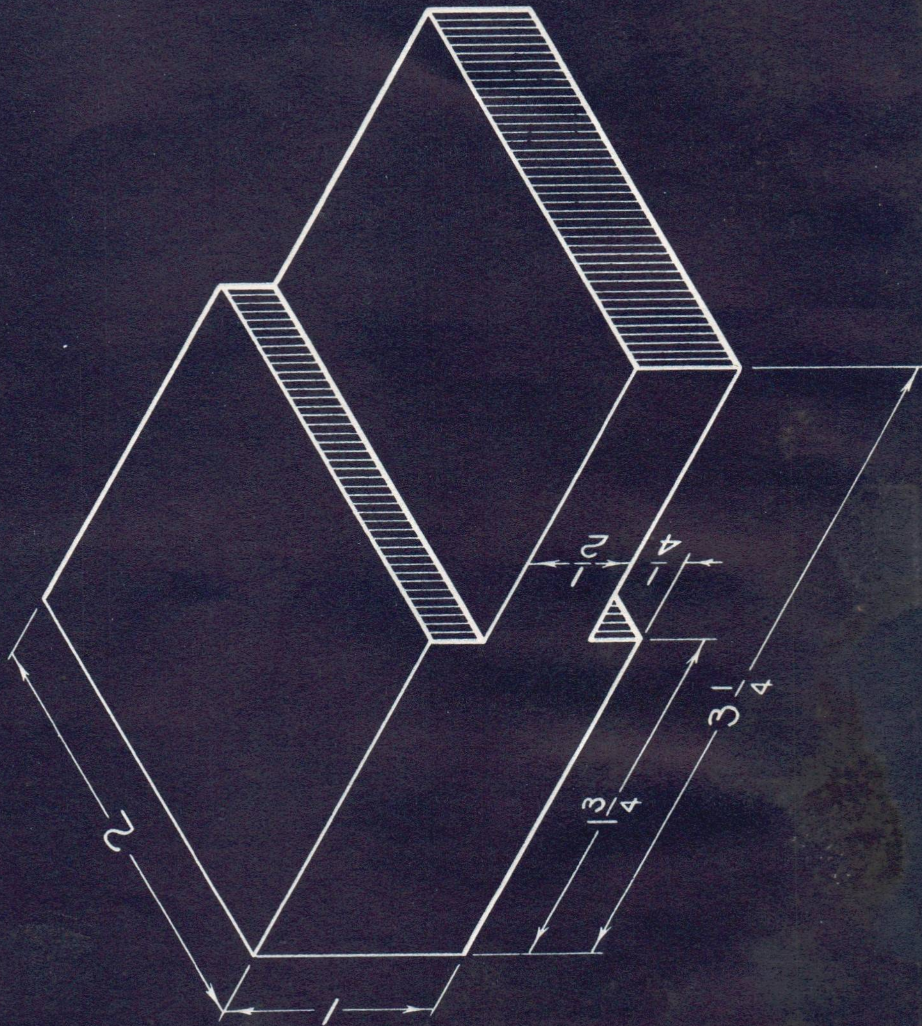
The three types of straight lines which are widely used in drawing and sketching are: (1) horizontal, (2) vertical and (3) inclined or slant lines.

The slant line may be drawn either from the top down or the bottom up. The use of dots at the starting and stopping points for slant lines is helpful to the beginner. These lines (Fig. 96) are produced with the same free arm movement used for horizontal and vertical lines.

USING GRAPH PAPER

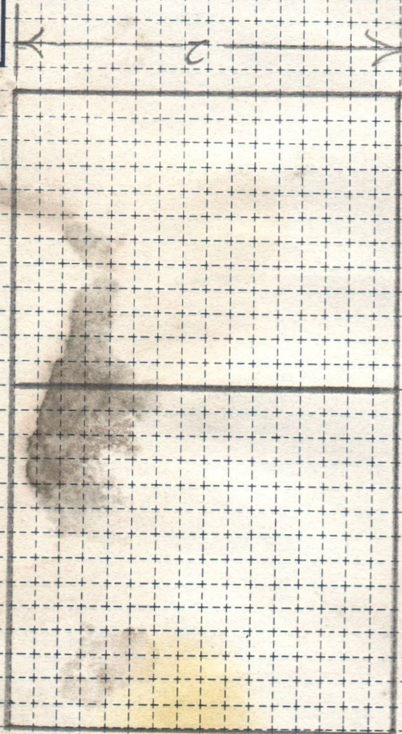
Many industries recommend the use of graph paper for making sketches. These graph papers are marked to show how many squares there are for each inch. The combination of light ruled lines at a fixed number per inch makes it possible to draw sketches fairly accurately to size, neater and faster. Throughout this monograph, squared graph sections are included for each sketching assignment.

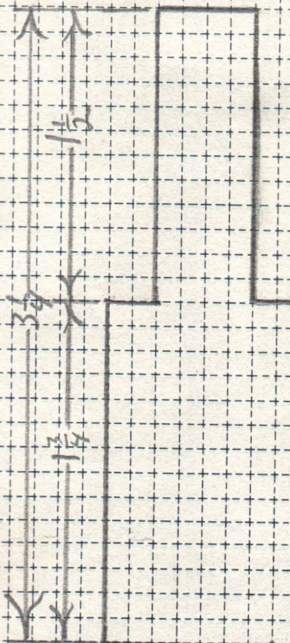
PUNCH PLATE BP-24 A

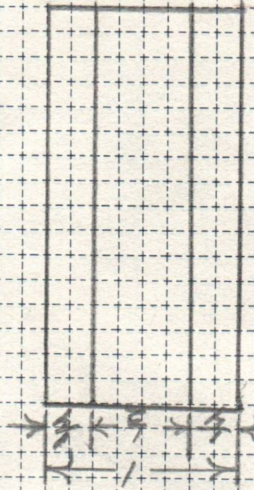


Assignment
Unit 24 A

Student's Name ______________







SKETCHING ASSIGNMENT FOR PUNCH PLATE (BP-24 A)

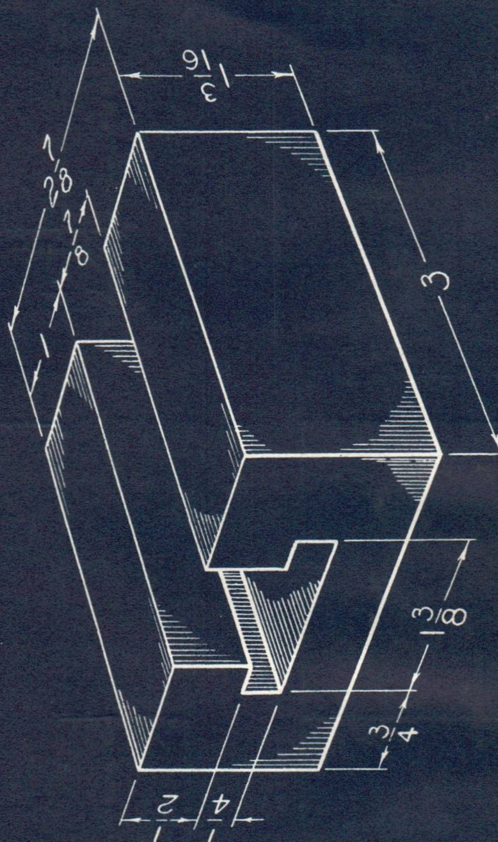
1. SKETCH THREE VIEWS: FRONT, TOP AND RIGHT SIDE
2. DIMENSION EACH VIEW

SUGGESTIONS

1. START THE FRONT VIEW 1" FROM THE LEFT HAND MARGIN AND 1/2" FROM THE BOTTOM
2. ALLOW 1" BETWEEN THE VIEWS

BP-24B

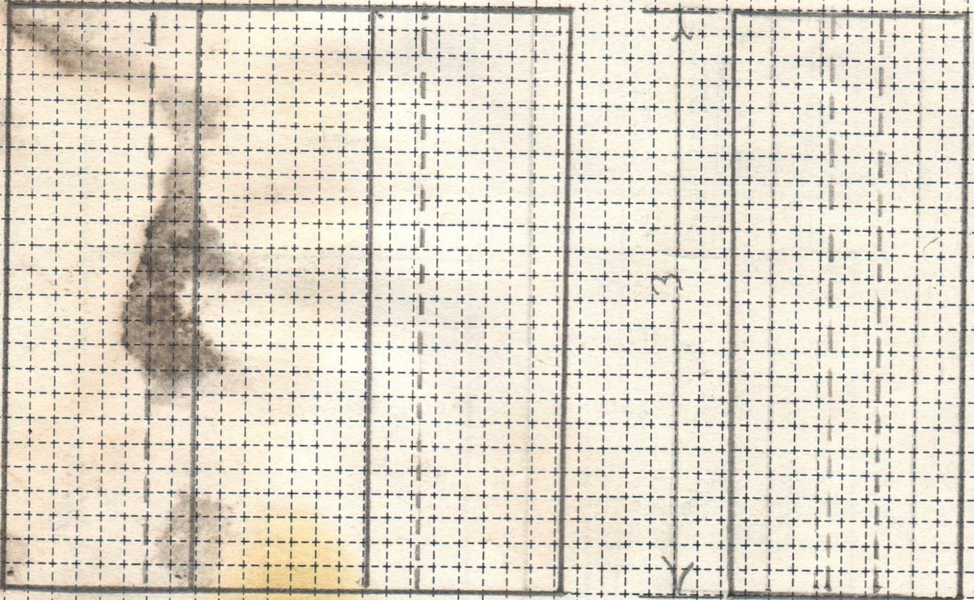
TEE SLIDE



Assignment

Unit 24B

Student's Name ____________



SKETCHING ASSIGNMENT FOR TEE SLIDE (BP-24 B)

1. MAKE FREEHAND SKETCHES OF THE FRONT, TOP AND LEFT SIDE VIEWS
2. DIMENSION THE VIEWS

SUGGESTIONS

1. CENTER THE SKETCHES ON THE SQUARED SECTIONS
2. ALLOW $3/4''$ BETWEEN THE VIEWS

Unit 25 SKETCHING CURVED LINES AND CIRCLES

SKETCHING CURVED LINES

ARCS CONNECTING STRAIGHT LINES

An analysis of drawings shows that, in order to describe a part, both straight and curved lines are often used in combination with each other. When part of a circle is shown, the curved line is usually referred to as an "arc".

Where an arc must be drawn so that it connects two straight lines (tangent to them), it may be sketched easily if five basic steps are followed. Each of these steps is illustrated in Figure 97.

STEP 1 ➧ Extend the straight lines so they intersect.

STEP 2 ➧ Step off on the vertical and horizontal center lines the same distance from the intersection (center) of both lines.

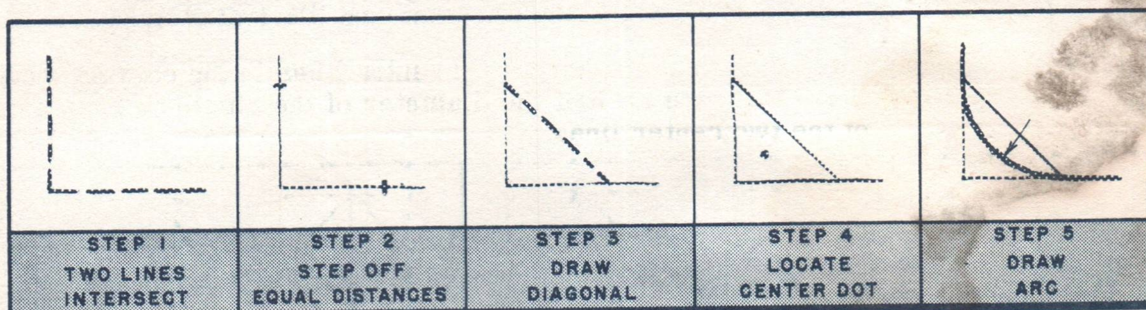


FIG. 97 SKETCHING AN ARC FREEHAND

STEP 3 ➧ Draw the diagonal line through these two points to form a triangle.

STEP 4 ➧ Place a dot in the center of the triangle.

STEP 5 ➧ Start at the vertical line and sketch an arc which runs through the dot and ends in the horizontal center line. Darken the arc and erase all unnecessary lines.

ARCS CONNECTING STRAIGHT AND CURVED LINES

Two other line combinations using straight lines and arcs are also very common. The first is the case of an arc connecting a straight line with another arc; the second, where an arc connects two other arcs. The same five basic steps are used as illustrated in Figure 98.

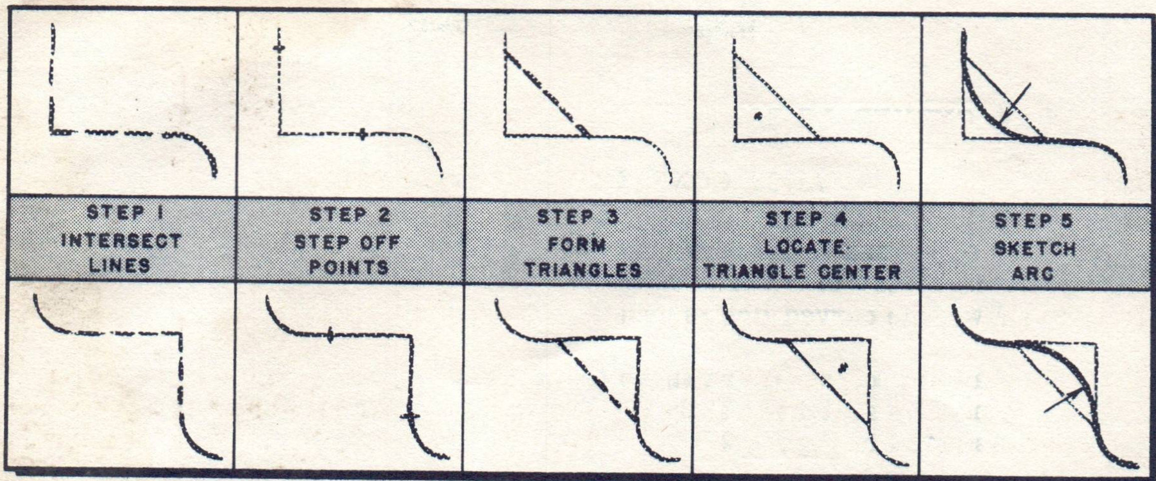


FIG. 98 SKETCHING ARCS IN COMBINATION WITH OTHER ARCS

SKETCHING CIRCLES

Shop sketches also require the drawing of circles or parts of a circle. While there are many ways to draw a circle freehand, a well formed circle can be sketched by following five simple steps which are described below and illustrated in Figure 99.

STEP 1 ➧ Lay out the vertical and horizontal center lines in the correct location. Measure off half the diameter of the circle on each side of the two center lines.

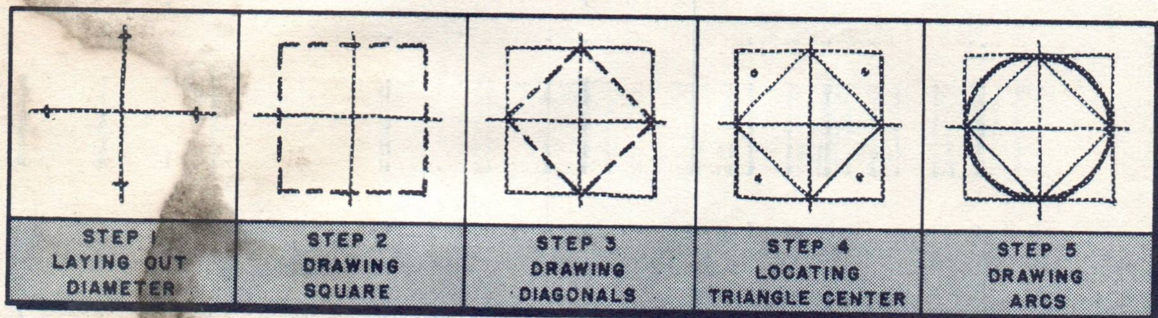


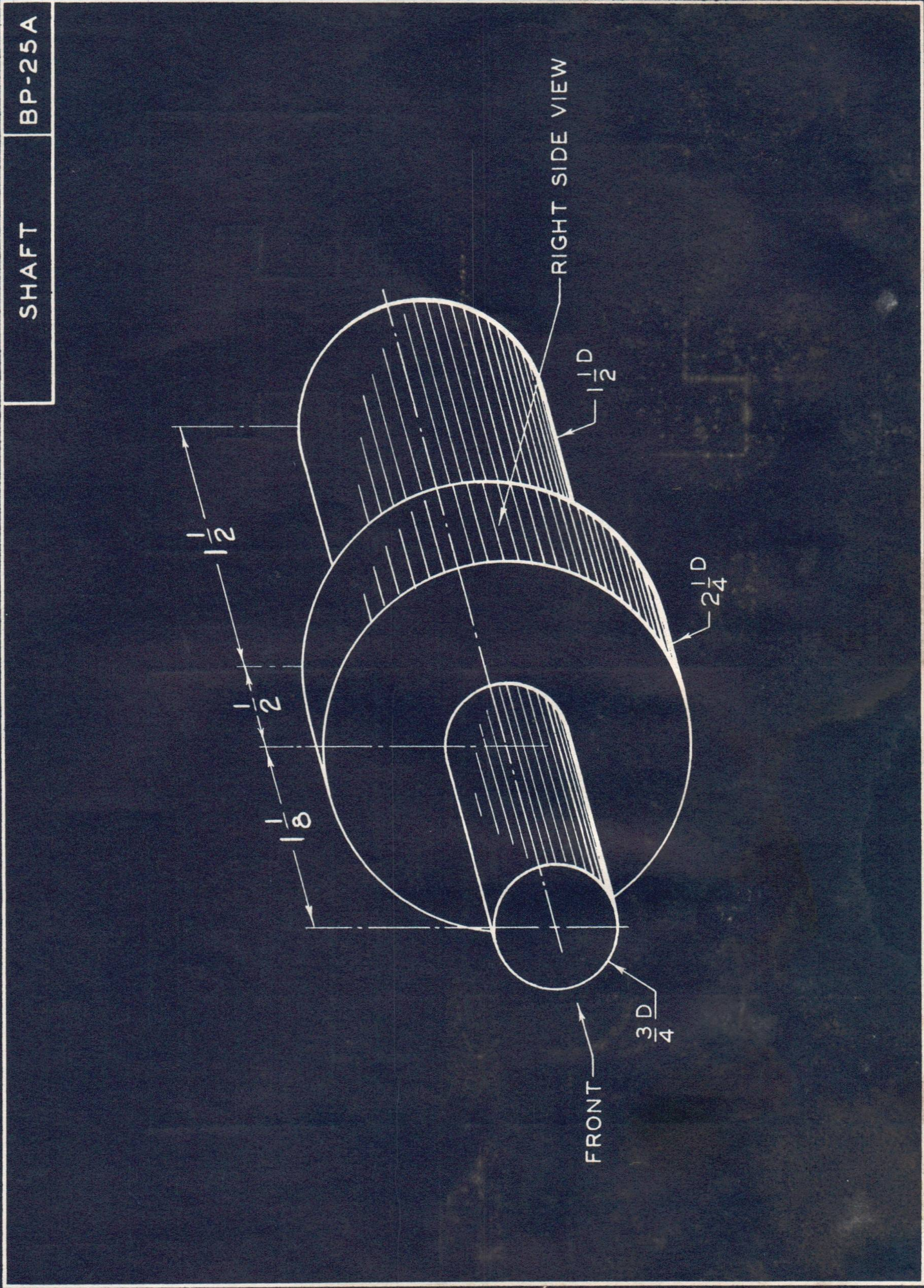
FIG. 99 SKETCHING A CIRCLE

STEP 2 ➧ Draw lightly two vertical and two horizontal lines passing through the points marked off on the center lines. These lines, properly drawn, will be parallel and will form a square.

STEP 3 ➧ Draw diagonal lines from each corner of the square to form four triangles.

STEP 4 ➧ Place a dot in the center of each triangle through which an arc is to pass.

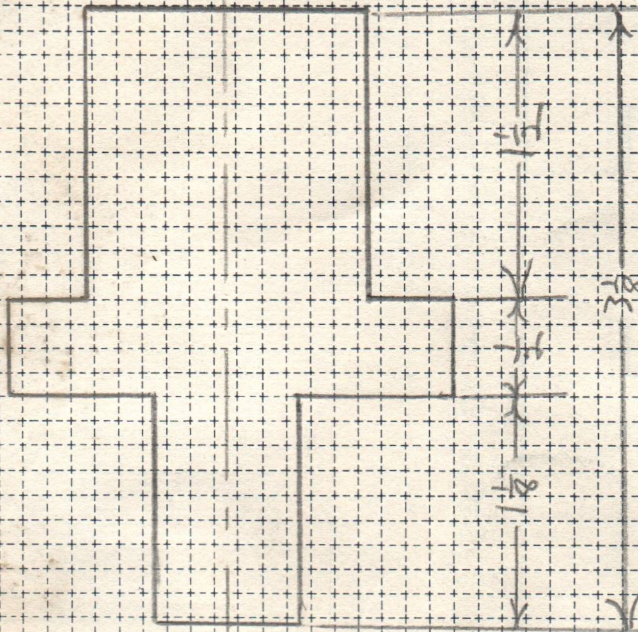
STEP 5 ➧ Sketch the arc for one quarter of the circle. Start at one center line and draw the arc through the dot to the next center line. Continue until the circle is complete. Darken the circle and erase all the guide lines in order to simplify the reading of the sketch.

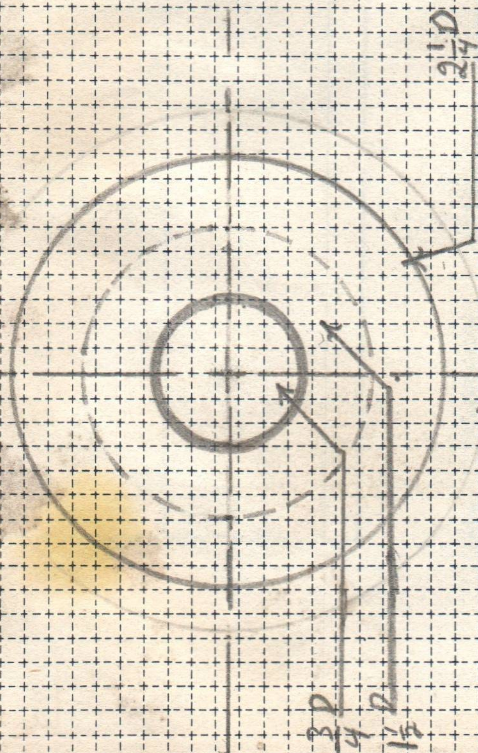

SHAFT
BP-25A
RIGHT SIDE VIEW
FRONT
1 1/2 D
2 1/4 D
3/4 D
1 1/2
1/2
1 1/8

Assignment

Unit 25A

Student's Name





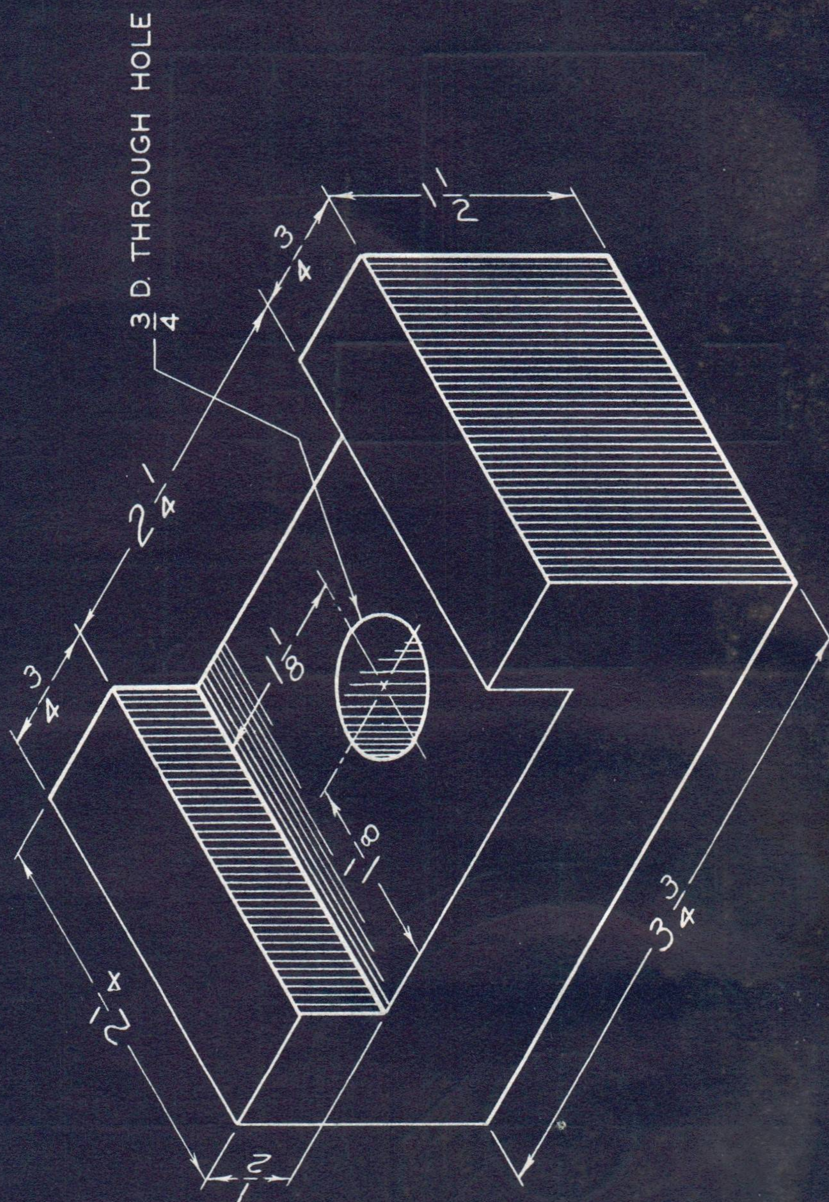
SKETCHING ASSIGNMENT FOR SHAFT (BP-25A)

1. SKETCH A FRONT AND RIGHT SIDE VIEW
2. DIMENSION BOTH VIEWS

SUGGESTIONS

1. DRAW VERTICAL CENTER LINE FOR FRONT VIEW 2" FROM LEFT BORDER
2. DRAW HORIZONTAL CENTER LINE 2 3/4" FROM BOTTOM BORDER
3. ALLOW 1" BETWEEW VIEWS

SLIDE BLOCK | BP-25B



Assignment Unit 25B

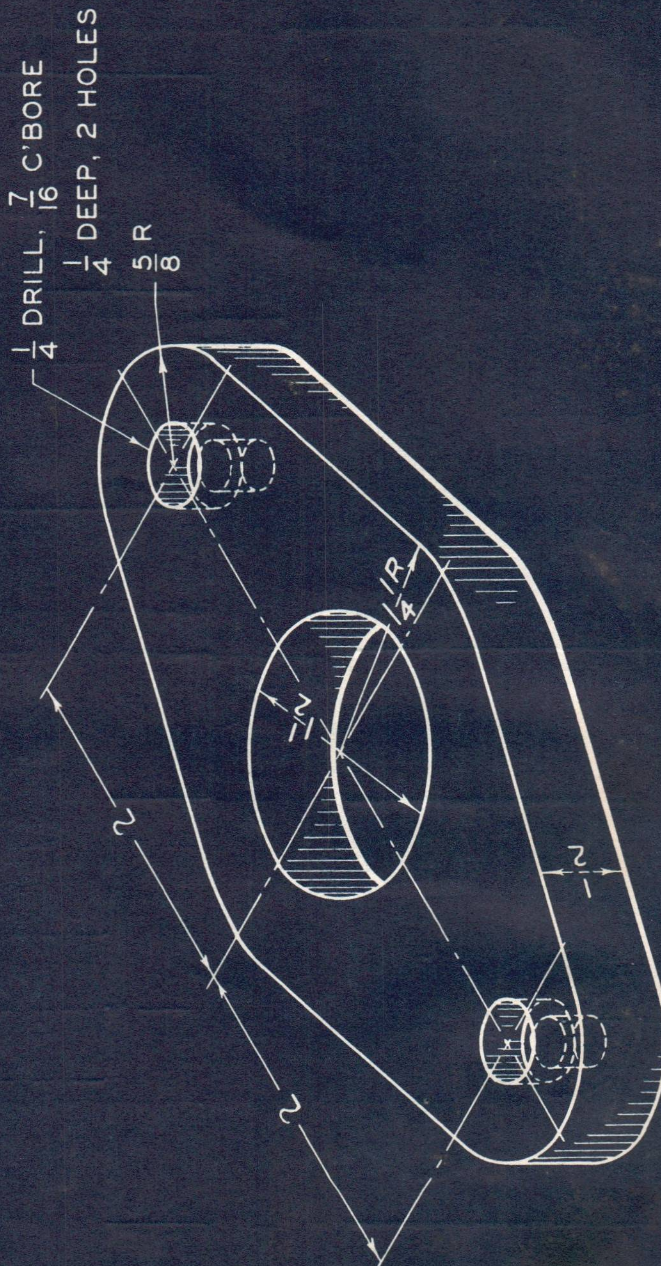
Student's Name

SKETCHING ASSIGNMENT FOR SLIDE BLOCK (BP-25B)

1. SKETCH THREE VIEWS: FRONT, TOP AND RIGHT SIDE
2. DIMENSION EACH VIEW OF THE SKETCH

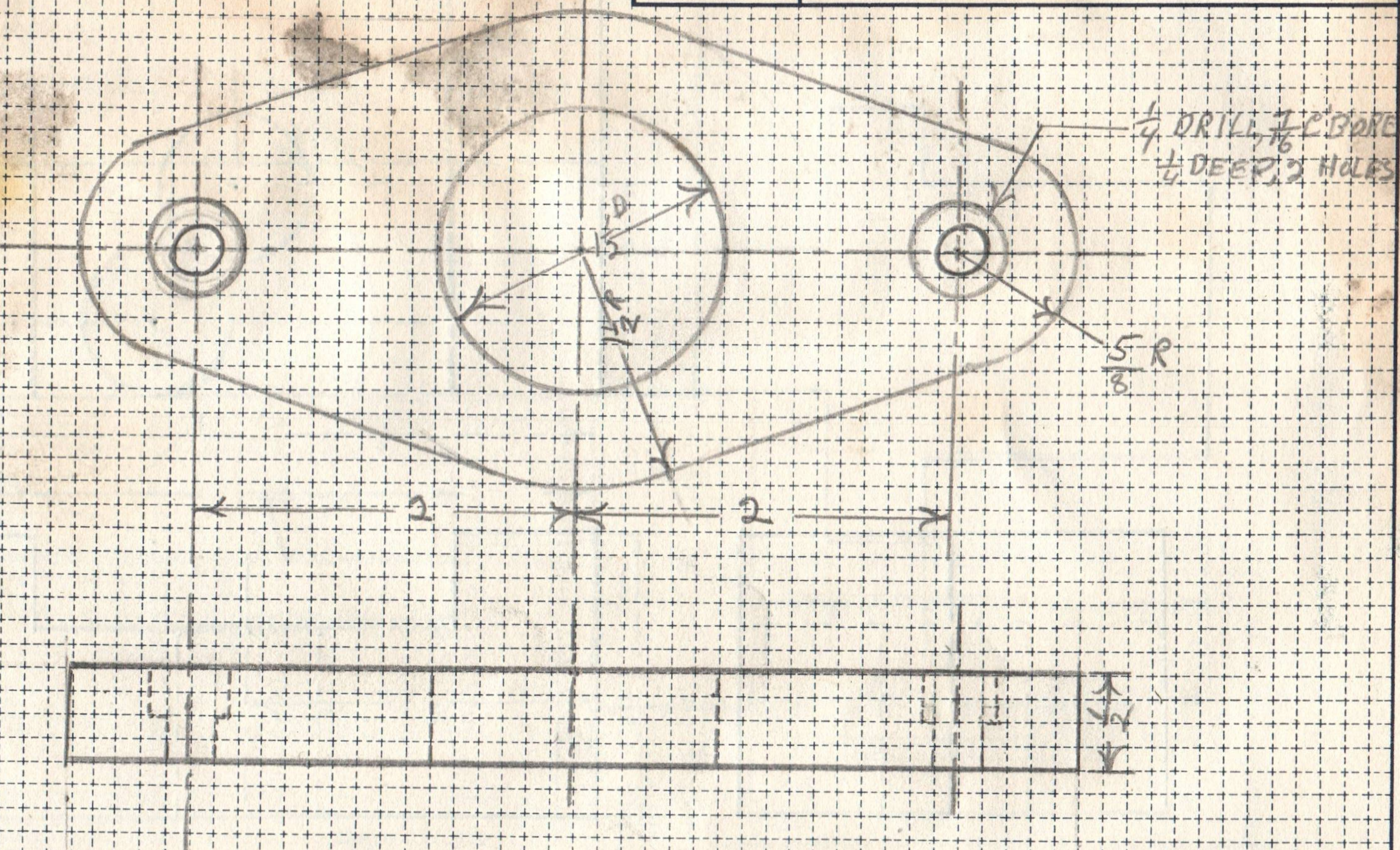
SUGGESTIONS

1. START THE FRONT VIEW 5/8" FROM THE LEFT HAND MARGIN AND 3/8" FROM THE BOTTOM
2. ALLOW 3/4" BETWEEN THE VIEWS


FLANGE
BP-25C
$\frac{1}{4}$ DRILL, $\frac{7}{16}$ C'BORE
$\frac{1}{4}$ DEEP, 2 HOLES
$\frac{5}{8}$ R

Assignment Unit 25C

Student's Name ______________________



SKETCHING ASSIGNMENT FOR FLANGE (BP-25C)

1. MAKE A FREEHAND SKETCH OF THE TOP AND FRONT VIEWS
2. DIMENSION THE VIEWS COMPLETELY

SUGGESTIONS

1. LAY OUT VERTICAL CENTER LINE SO THE SKETCH IS POSITIONED ON THE SHEET
2. LAY OUT HORIZONTAL CENTER LINE FOR TOP VIEW
3. ALLOW 1" BETWEEN VIEWS

Unit 26 SKETCHING IRREGULAR SHAPES

Parts that are irregular in shape and look complicated to sketch are often drawn easily if the object is first visualized as a series of square and rectangular blocks. Then by using straight, slant and curved lines in combination with each other, it is possible to draw in the squares and rectangles the exact shape of the part.

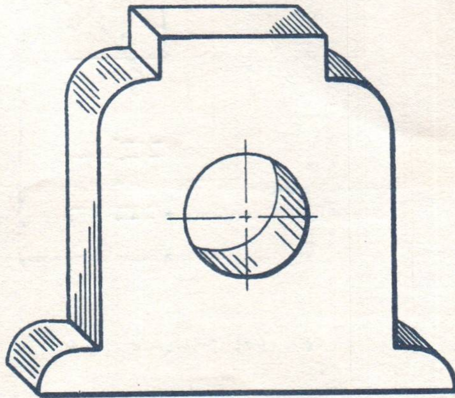
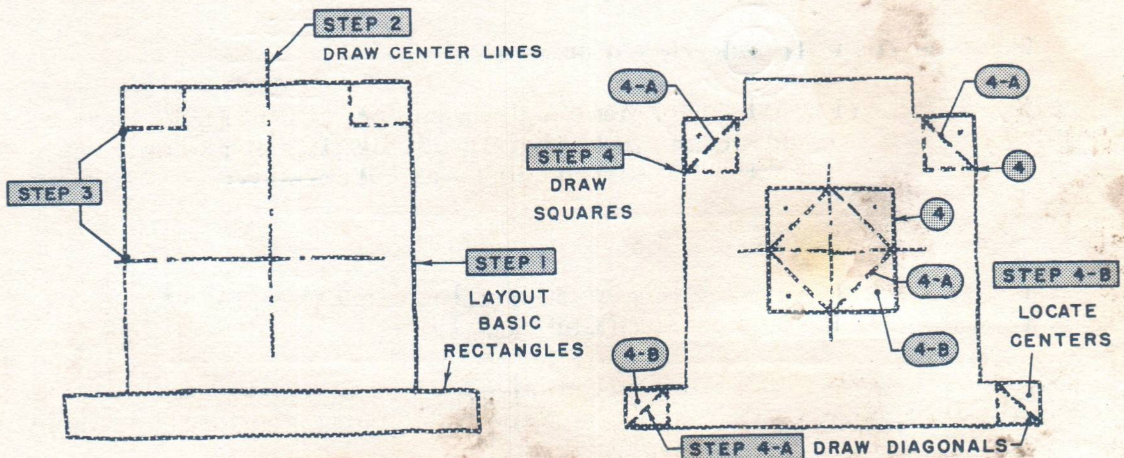


FIG. 100 EXAMPLE OF IRREGULAR SHAPED PART TO BE SKETCHED

The Shaft Support shown in Figure 100 is an example of a machined part that can be sketched easily by "blocking". The support must first be thought of in terms of basic squares and rectangles. After these squares and rectangles are determined, the step-by-step procedures which are commonly used to simplify the making of a sketch of an irregularly shaped piece are described below and are illustrated in Figure 101.

STEP 1 Lay out the two basic rectangles required for the shaft support. Use light lines and draw the outline to the desired overall sketch size.

STEP 2 Place a dot at the center of the top horizontal line and draw the vertical center line. Also, draw two vertical lines for the sides of the top rectangle.



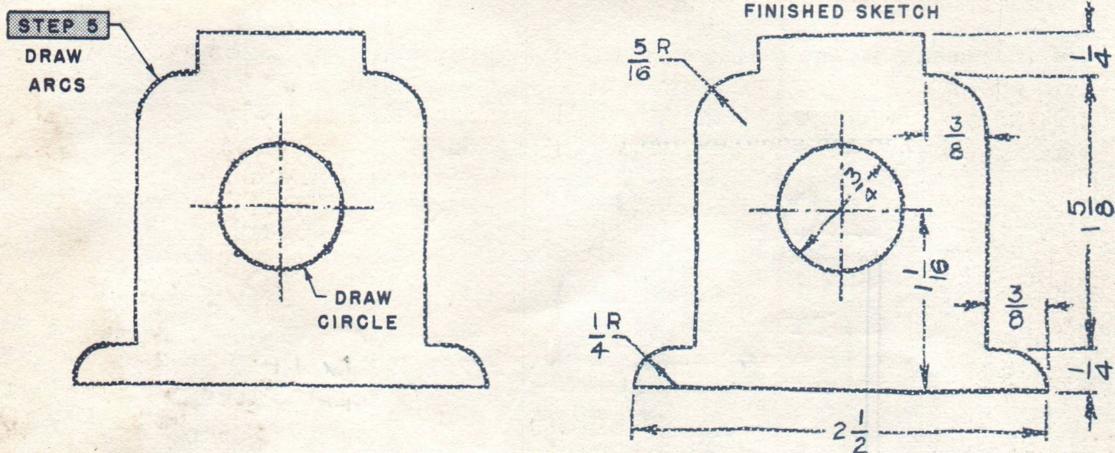


FIG. 101 STEPS IN SKETCHING AN IRREGULAR SHAPE

STEP 3 ➧ Locate dots and draw horizontal lines from the left vertical line to locate:

(a) The rectangle for the top of the support, and
(b) The center line of the hole.

STEP 4 ➧ Draw the squares for the rounded corners of the base, top and the center hole. In these squares:

(a) Draw the diagonals and form the triangles, and
(b) Locate dots in the centers of the triangles through which each arc will pass.

STEP 5 ➧ Draw the arcs and circle. Start at one diagonal and draw the arc through the dot to the next diagonal. Continue until the circle is completed.

STEP 6 ➧ Draw the side view if necessary.

STEP 7 ➧ Darken all object lines and dimension. Erase those lines used in construction that either do not simplify or are not required to interpret the sketch quickly and accurately.

The techniques described in this unit have been found by tested experience to be essential in training the beginner to sketch accurately.

As skill is developed in drawing straight, slant and curved lines freehand in combination with each other, some of the steps in sketching irregularly shaped parts may be cut out and the process shortened.

TOOL BLOCK BP-26

.625 REAM
$1\frac{1}{4}$ D SPOTFACE
TO $\frac{1}{8}$ DEEP

$\frac{3}{4}$ $\frac{5}{8}$

FRONT VIEW

MATERIAL SAE 1080

1 R

A A

$\frac{5}{8}$

$1\frac{1}{2}$

$2\frac{1}{4}$

TOP VIEW

$\frac{3}{8}$

$\frac{1}{2}$

1

$\frac{1}{2}$ R

2

Assignment Unit 26

Student's Name

SKETCHING ASSIGNMENT FOR TOOL BLOCK (BP-26)

1. MAKE A FREEHAND SKETCH OF THE FRONT VIEW AND TOP VIEW
2. SKETCH FULL SECTION A-A
3. DIMENSION FRONT AND TOP VIEWS

SUGGESTIONS

1. START FRONT VIEW 1" FROM LEFT BORDER AND $\frac{3}{16}$" FROM BOTTOM BORDER
2. ALLOW $1\frac{1}{2}$" BETWEEN VIEWS

Unit 27 SKETCHING FILLETS, RADII, ROUNDED CORNERS AND EDGES

Wherever practical, sharp corners are rounded and sharp edges are eliminated. This is true of fabricated and hardened parts, where a sharp corner reduces the strength of the object, and on castings where sharp edges and corners may be difficult to produce (Fig. 102).

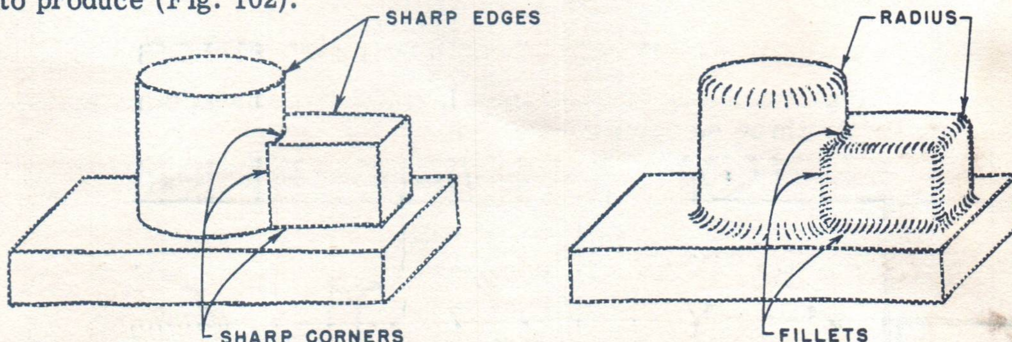


FIG. 102 ELIMINATING SHARP EDGES AND CORNERS

Where an outside edge is rounded, the convex edge is called a "rounded edge" or "radius". A rounded inside corner is known as a "fillet".

SKETCHING A FILLET OR RADIUS

Regardless of whether a fillet or radius is required, the steps for sketching each one are identical. The step-by-step procedure is illustrated in Figure 103.

	STEP 1	STEP 2	STEP 3	STEP 4
SKETCHING A FILLET				FILLET COMPLETED
SKETCHING A RADIUS				RADIUS COMPLETED

FIG. 103 STEPS IN SKETCHING A FILLET OR RADIUS

STEP 1 ➧ Sketch the lines which represent the edge or corner.

STEP 2 ➧ Draw the arc to the prescribed radius.

STEP 3 ➧ Draw two lines parallel to the edge line from the two points where the arc touches the straight lines.

STEP 4 ➧ Sketch a series of curved lines across the work with the same arc as the object line. These curved lines start at one of the parallel lines and terminate at the other.

SKETCHING INTERSECTING RADII AND FILLETS

The sketching of corners at which radii or fillets come together may be done as illustrated in the three steps in Figure 104.

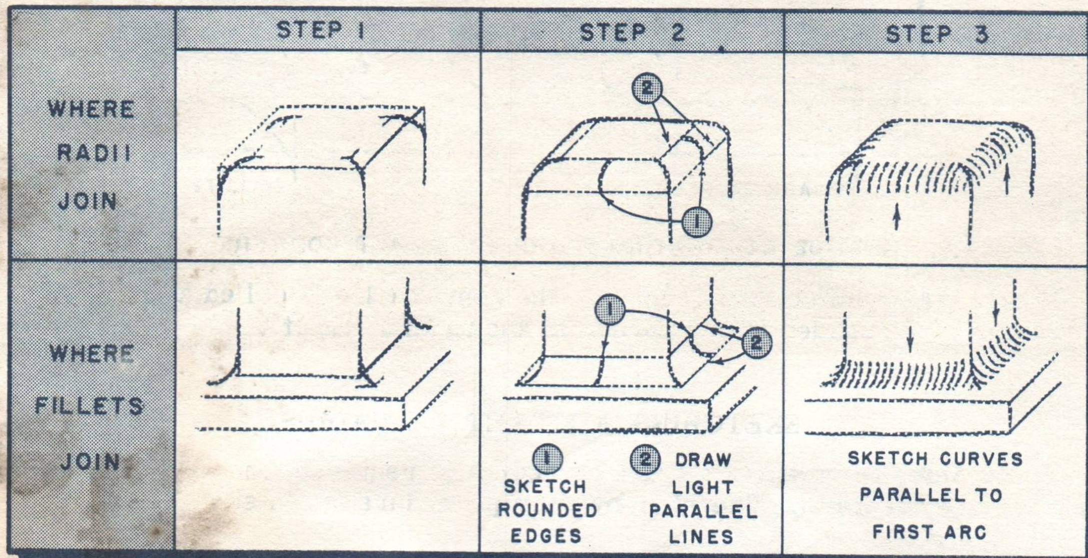


FIG. 104 SKETCHING ROUNDED CORNERS AND EDGES

SKETCHING CORNERS ON CIRCULAR PARTS

The direction of radius or fillet lines changes on circular objects at a center line. The curved lines tend to straighten as they approach the center line and then slowly curve in the opposite direction beyond that point. The direction of curved lines for outside radii of round parts is shown at (A), Figure 105. The curved lines for the intersecting corners are illustrated at (B).

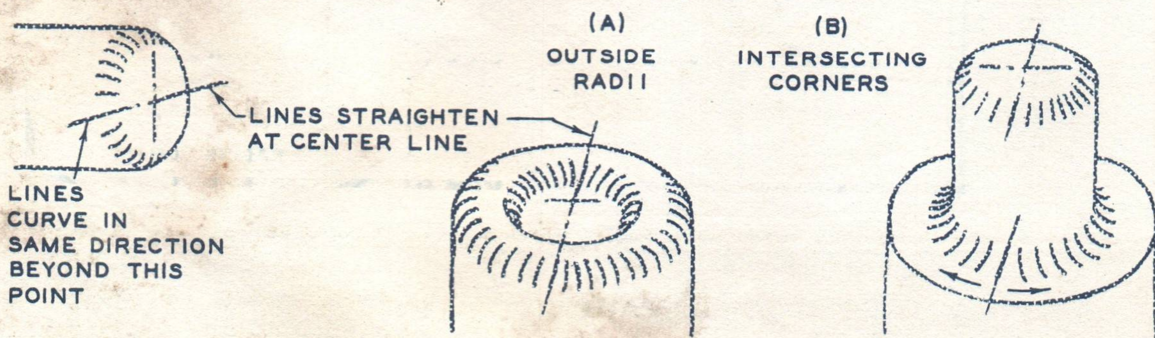
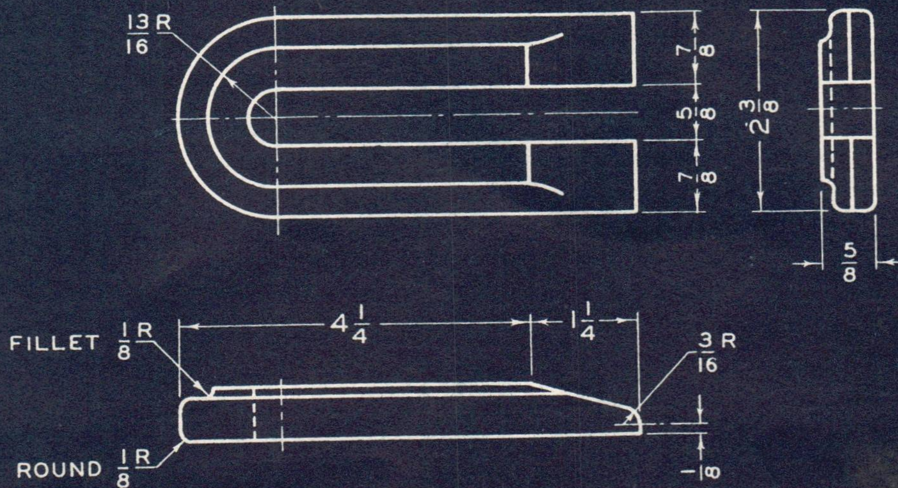
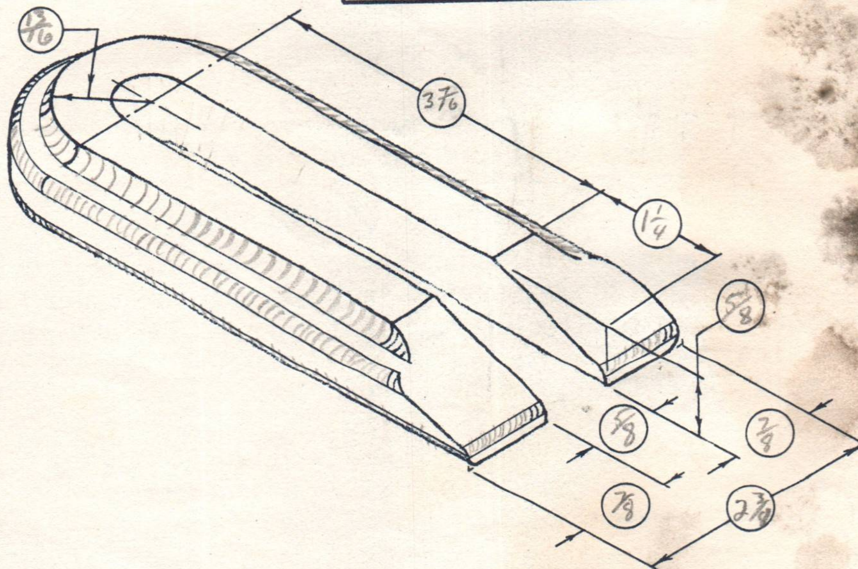


FIG. 105 DIRECTION OF CURVED LINES ON ROUND PARTS

DROP FORGED STRAP	BP-27 A

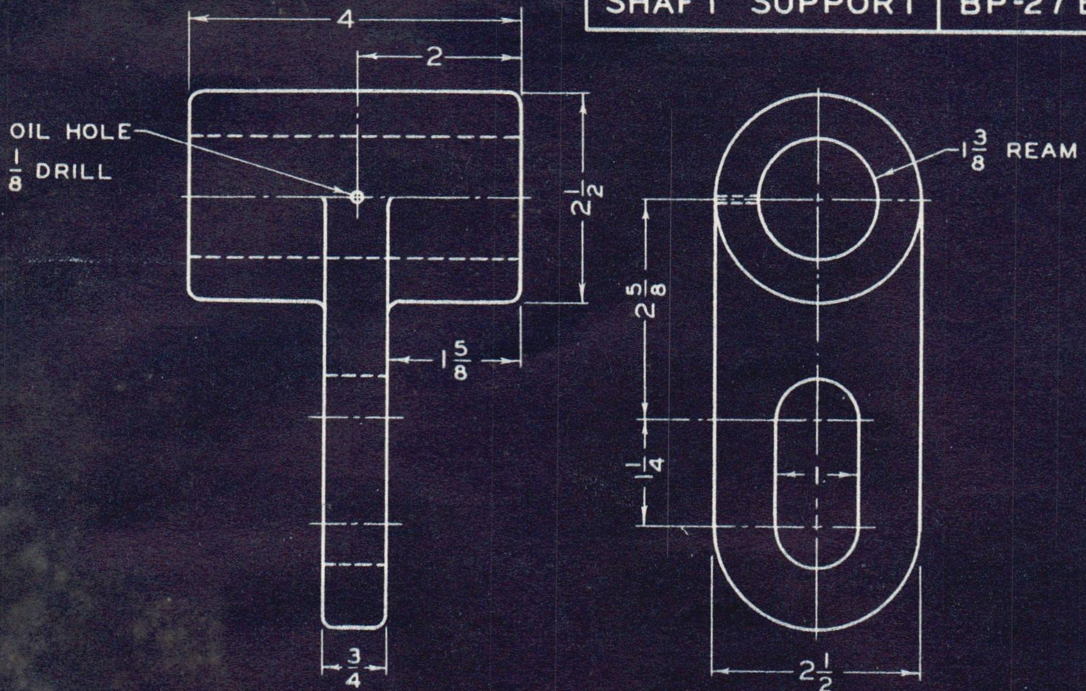


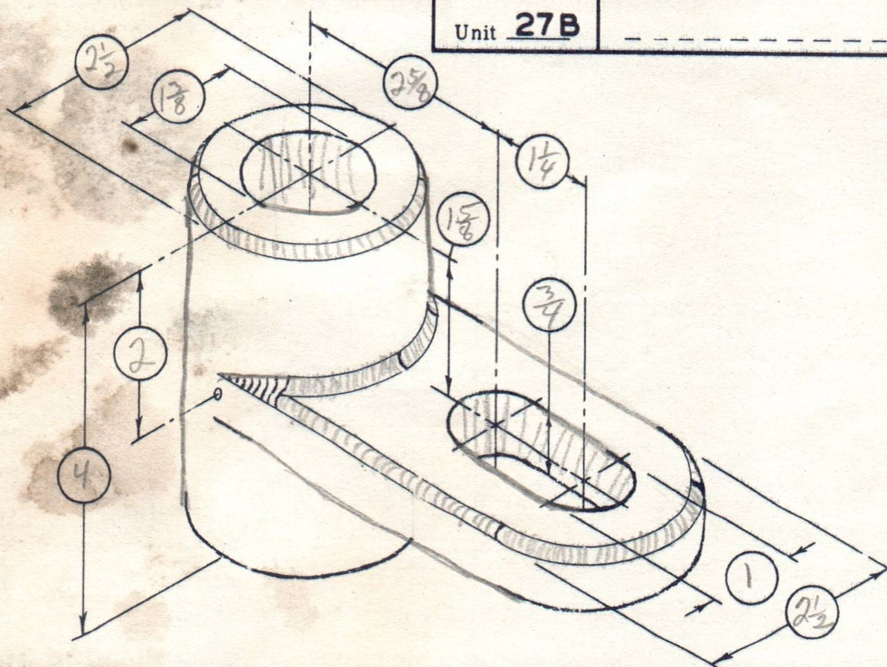
Assignment Unit 27A	Student's Name



SKETCHING ASSIGNMENT FOR DROP FORGED STRAP (BP-27A)

1. COMPLETE THE SKETCH BY SHADING THE FILLETED CORNER AND THE ROUNDED EDGES.
2. DIMENSION THE SKETCH. PLACE DIMENSIONS IN THE CIRCLES PROVIDED FOR THEM.





Assignment Unit 27B

Student's Name ____________________

SKETCHING ASSIGNMENT FOR SHAFT SUPPORT (BP-27B)

1. COMPLETE THE SKETCH AND SHADE THE ROUNDED CORNERS AND FILLET.
2. DIMENSION THE SKETCH. PLACE DIMENSIONS IN CIRCLES PROVIDED FOR THEM.

Unit 28 FREEHAND VERTICAL LETTERING

The true shape of a part or mechanism may be described accurately on a drawing by using combinations of lines and views. Added to these are the lettering which supplies additional information, and the dimensions. Sometimes, on exceptionally accurate work and for standardization of shape and size, the lettering is done with a guide. In most other cases the letters are formed freehand.

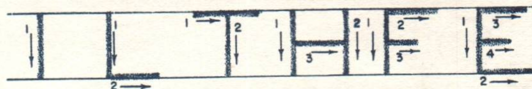
An almost square style letter known as "Gothic lettering" is very widely used because it is legible and the individual letters are simple enough to be made quickly and accurately. Gothic letters may be either vertical (straight) or inclined (slant), and upper or lower case.

VERTICAL LETTERING

FORMING UPPER CASE LETTERS

The shape of each vertical letter (both upper and lower case) and each number will be discussed in this unit. All of these letters and numbers are formed by combining vertical, horizontal, slant and curved lines. The upper case letters should be started first as they are easiest to make.

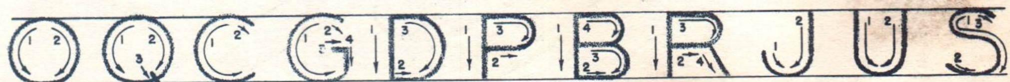
Very light guide lines should be used to keep the letters of uniform height and straight. A soft pencil is recommended for lettering because it is possible to guide the pencil easily to form good letters.



LETTERS FORMED WITH VERTICAL AND HORIZONTAL LINES



LETTERS FORMED WITH VERTICAL, HORIZONTAL AND SLANT LINES



LETTERS FORMED WITH STRAIGHT AND CURVED LINES

FIG. 106 FORMING UPPER CASE LETTERS

The shape of each vertical letter and number is given in Figures 106, 107 and 108. The light lines with arrows which appear with every letter give the direction and number of the strokes needed to form the letter. The small numbers indicate the sequence of the strokes. Note that most letters are narrower than they are long. Lettering is usually done with a single stroke in order to keep the line weight of each letter uniform.

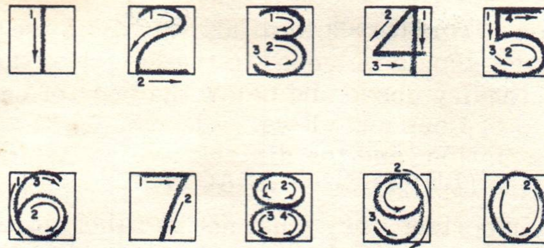


FIG. 107 FORMING VERTICAL NUMERALS

SPACING LETTERS

For good lettering, attention must be given to proper spacing between letters, words and lines. Words and lines that are either condensed and run together or spread out are difficult to read, cause inaccuracies and detract from an otherwise good drawing.

The space between letters should be about one-fourth the width of a regular letter. For example, the slant line of the letter 'A' would be one-quarter letter away from the top line of the letter 'T'. Judgment must be used in the amount of space left so that there is as nearly an equal amount of white space between letters as possible. The letters will then look in balance and will be easy to read.

Between words, a space two-thirds the full width of a normal letter should be used. Lines of lettering are easiest to read when a space of from one-half to the full height of the letters is left between the lines.

LOWER CASE VERTICAL LETTERS

SHAPES OF LOWER CASE LETTERS

Lower case Gothic letters are formed in a manner different from that of upper case. The main portion, or body, of most Gothic lower case letters is approximately the same width and height. The parts that extend above or below the body are one-half the height. The shape of each vertical lower case letter and the forming of the letters are indicated in Figure 108.

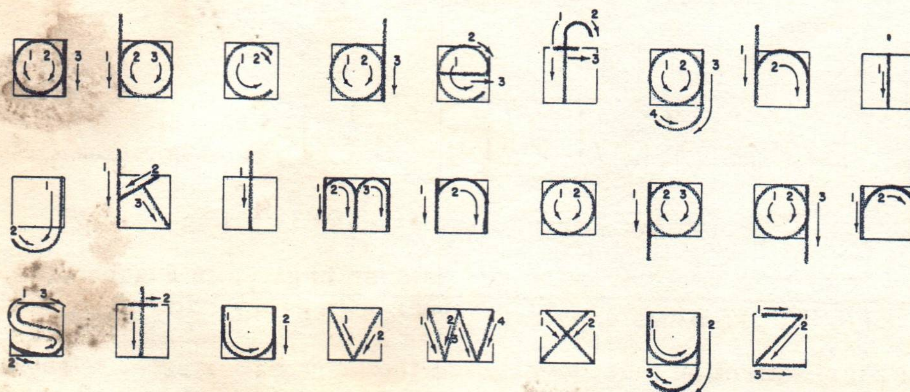


FIG. 108 FORMING VERTICAL LOWER-CASE LETTERS

The spacing between lower case letters and words is the same as for capitals. The spacing between lines should be equal to the height of the body of the letter to take care of the lines extending above and below the body of certain letters.

LETTERING FRACTIONS

Since fractions are important, they must not be subordinate to any of the lettering. The height of each number in the numerator and the denominator should be equal to not less than two-thirds the height of a whole number. The dividing line should be in the center of the whole number. There should also be a space between the numerator, the division sign and the denominator so that neither number touches the line. (Fig. 109)

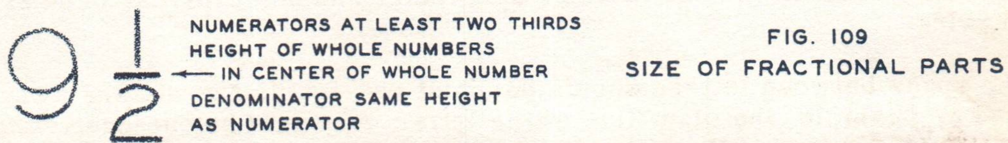


FIG. 109
SIZE OF FRACTIONAL PARTS

LETTERING RIGHT OR LEFT-HANDED

Thus far, the forming of letters has been in terms of lettering with the right hand. Analysis of the steps followed in lettering with the left hand shows that the strokes are often reversed. Figure 110 may be used as a guide for forming letters with the left hand.

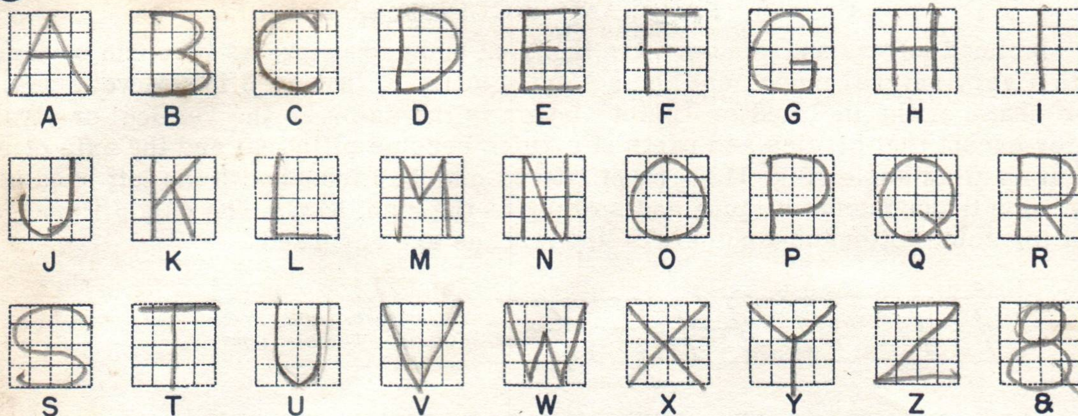
UPPER CASE LETTERS

LOWER CASE LETTERS

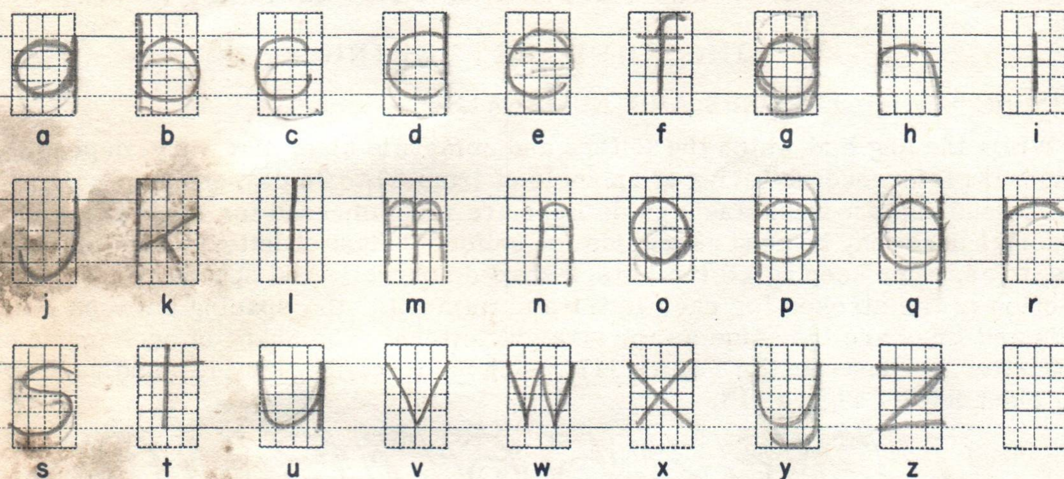
NUMERALS

FIG. 110 FORMING VERTICAL LETTERS WITH THE LEFT HAND

At the start, attention must be given to the proper forming of letters, uniform line weights and correct spacing. Speed may then be developed by continual practice in lettering words and sentences freehand.







UNLESS OTHERWISE SPECIFIED
LIMITS ON DIMENSIONS ARE:
FRACTIONAL DIMENSIONS ± $\frac{1}{64}$"
DECIMAL DIMENSIONS ± .001"
ANGULAR DIMENSIONS ± $\frac{1}{2}$°

(2) UNLESS OTHERWISE SPECIFIED
LIMITS ON DIMENSIONS ARE:
FRACTIONAL DIMENSIONS ± $\frac{1}{64}$"
DECIMAL DIMENSIONS ± .001"
ANGULAR DIMENSIONS ± $\frac{1}{2}$°

SKETCHING ASSIGNMENT FOR FREEHAND VERTICAL LETTERING (BP-28)

(1) LETTER FREEHAND THE UPPER AND LOWER CASE STRAIGHT LETTERS AND NUMERALS IN THE RULED SPACES PROVIDED

(2) LETTER THE NOTE ON TOLERANCES IN UPPER CASE LETTERS

Unit 29 FREEHAND INCLINED LETTERING

Inclined letters and numbers are found on many drawings as they can be formed with a very natural movement and a slant similar to that used in everyday writing. The shape of the inclined or "slant" letter is the same as the vertical or straight letter except that circles and parts of circles become elliptical and the axis of each letter is at an angle (Fig. 111). Slant letters may be formed with the left hand using the same techniques of shaping and spacing as the right hand. The only difference is that for some letters and numerals the strokes are reversed.

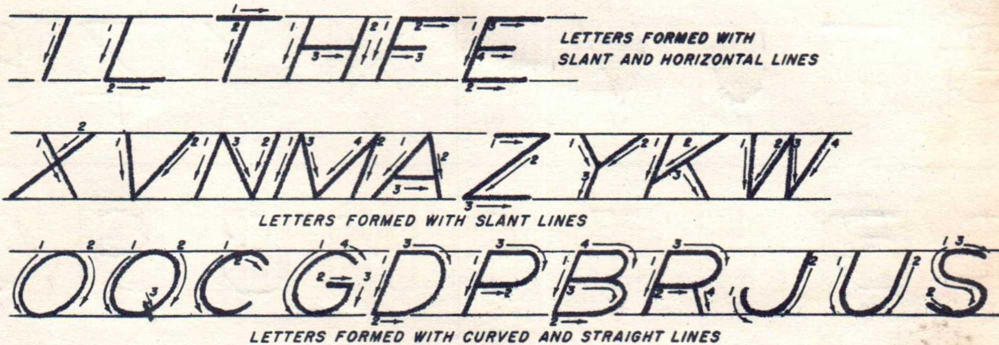


FIG. 111 FORMING UPPER CASE SLANT LETTERS

INCLINED LETTERING

FORMING SLANT LETTERS AND NUMERALS

While the angle at which the letters and numerals slant may vary, depending on individual preference, lettering at an angle of from 60 to 75 degrees is practical and easy to read and produce. Light guide lines are recommended for the beginner. The horizontal lines may be used as a guide for uniform height of letters; the angle guide lines, to assist in keeping all the letters shaped correctly and spaced properly. The direction of the strokes for each letter and numeral, the spacing between letters, words and lines are the same as for straight letters. The shape of each upper case slant letter is illustrated in Figure 111; each numeral. Figure 112; and each lower case slant letter, Figure 113.

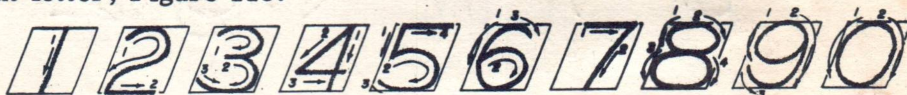


FIG. 112 FORMING SLANT NUMERALS

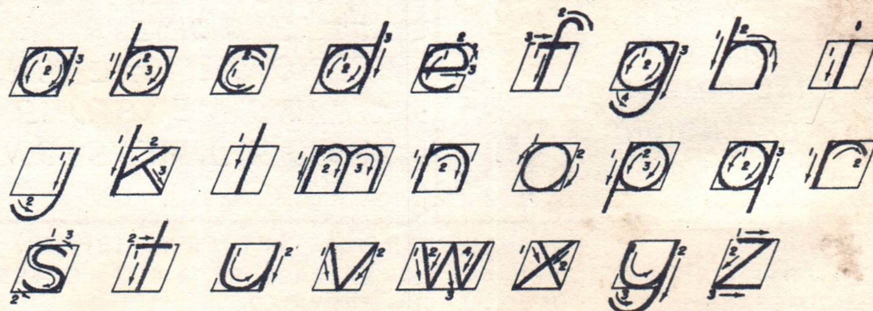
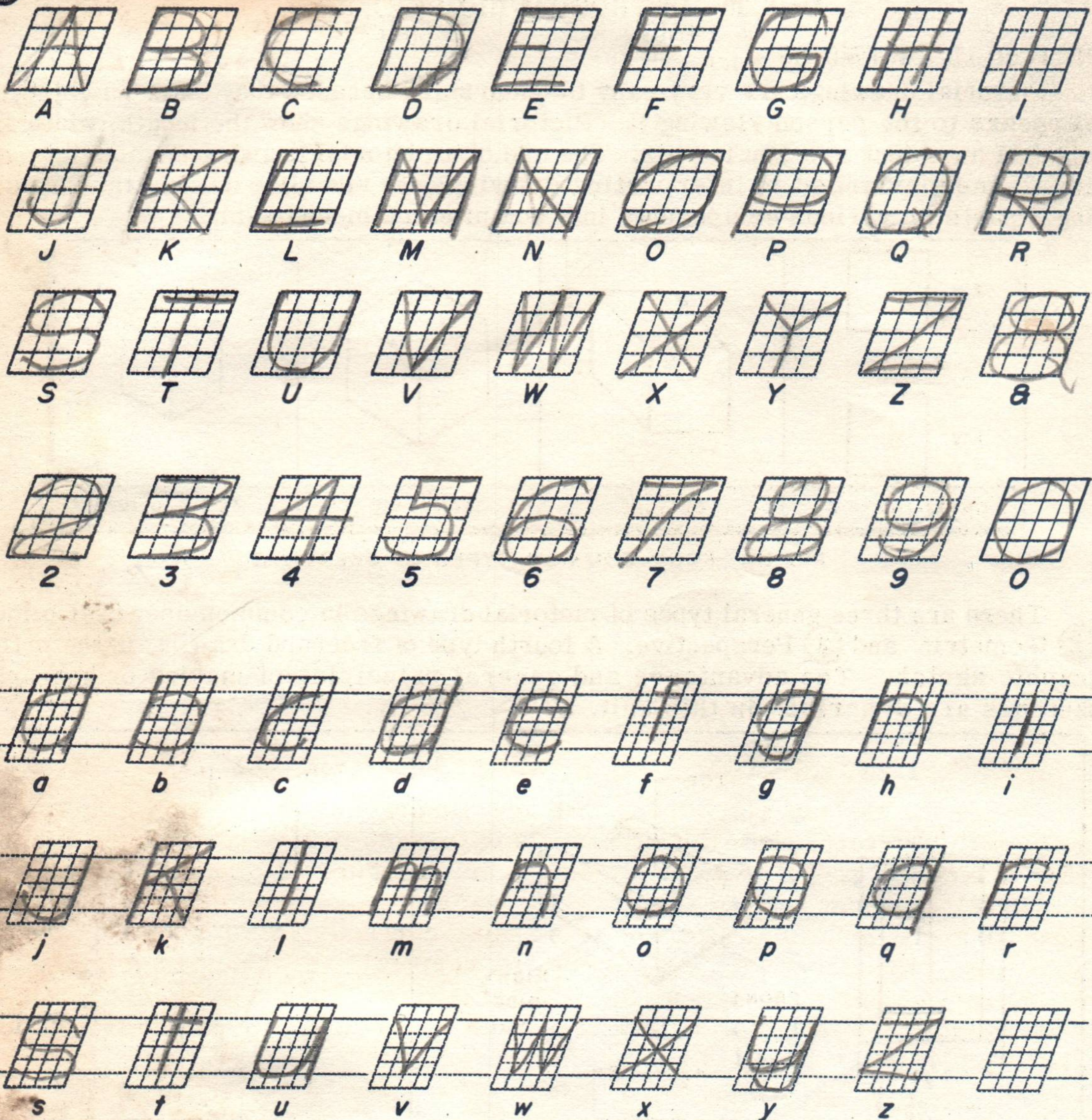


FIG. 113 FORMING LOWER CASE SLANT LETTERS



UNLESS OTHERWISE SPECIFIED
LIMITS ON DIMENSIONS ARE:
FRACTIONAL DIMENSIONS $\pm \frac{1}{64}''$
DECIMAL DIMENSIONS $\pm$ .001"
ANGULAR DIMENSIONS $\pm \frac{1}{2}°$

②

SKETCHING ASSIGNMENT FOR FREEHAND SLANT LETTERING (BP-29)

① LETTER FREEHAND THE UPPER AND LOWER CASE SLANT LETTERS AND NUMERALS IN THE RULED SPACES PROVIDED

② LETTER THE NOTE ON TOLERANCES IN UPPER CASE LETTERS

Unit 30 ORTHOGRAPHIC SKETCHING

PICTORIAL DRAWINGS

Pictorial drawings are very easy to understand because they show an object as it appears to the person viewing it. Pictorial drawings show the length, width and height of an object in a single view. The use of a pictorial drawing enables an individual, inexperienced in interpreting drawings, to visualize quickly the shape of single parts or various components in a complicated mechanism.

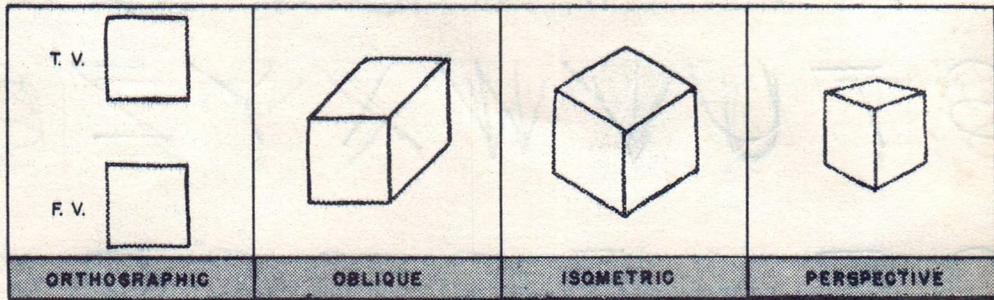


FIG. 114 FOUR COMMON TYPES OF SKETCHES

There are three general types of pictorial drawings in common use: (1) Oblique, (2) Isometric and (3) Perspective. A fourth type of freehand drawing is the orthographic sketch. The advantages and general principles of making orthographic sketches are described in this unit.

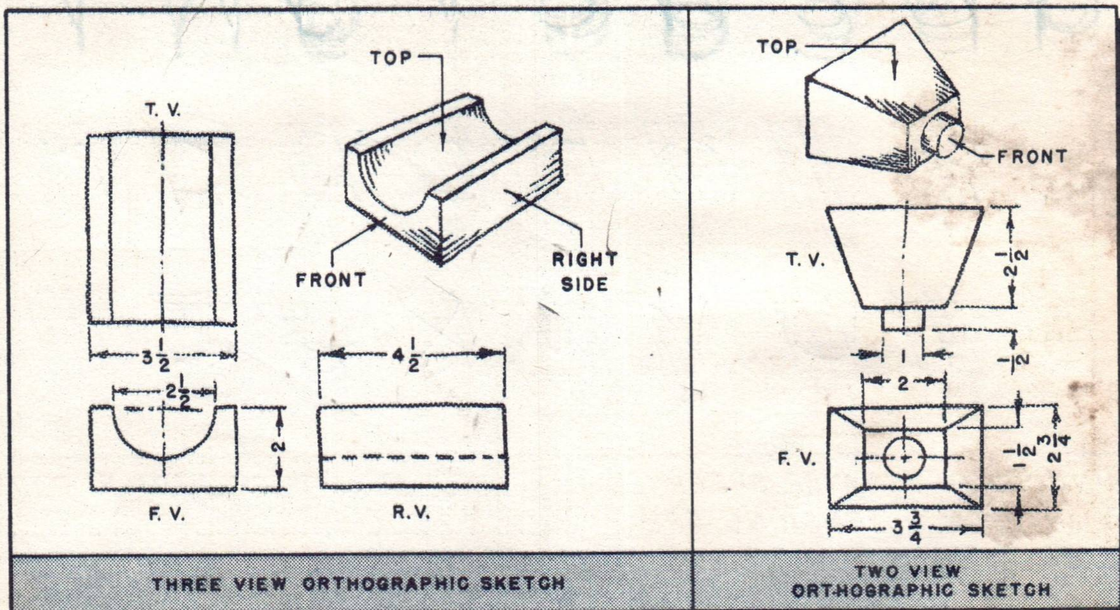
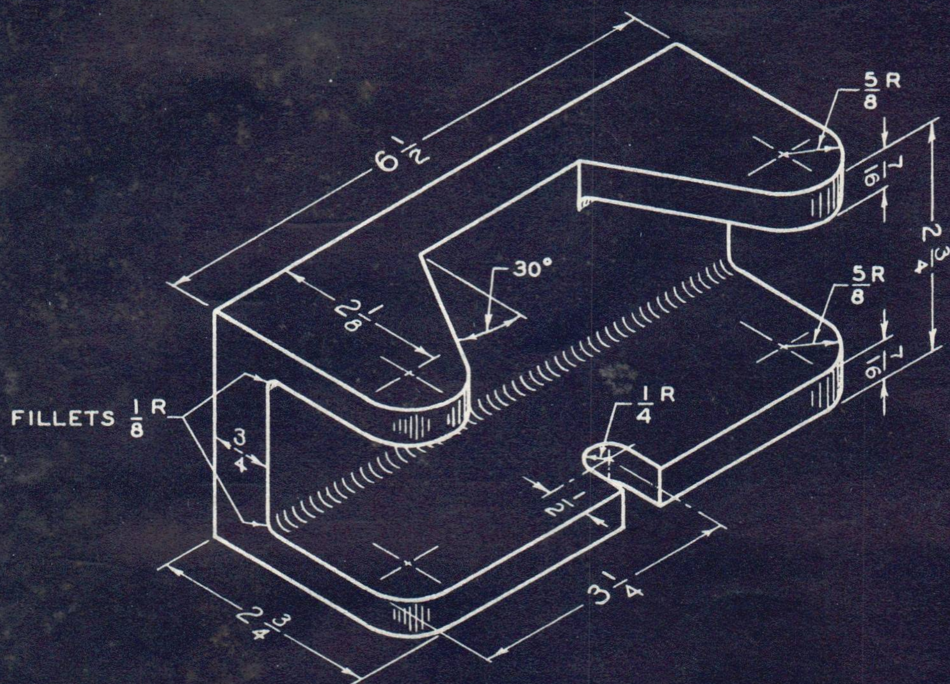


FIG. 115 EXAMPLES OF ORTHOGRAPHIC SKETCHES

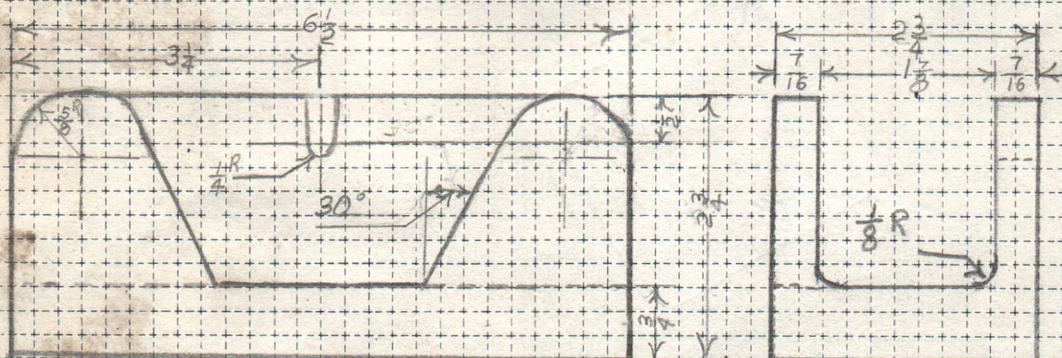
MAKING ORTHOGRAPHIC SKETCHES

The orthographic sketch is the simplest type to make. The views are developed as in any regular mechanical drawing and the same types of lines are used. The only difference is that orthographic sketches are drawn freehand. In actual practice, on-the-spot sketches of small parts are made as near the actual size as possible.



ROCKER FIXTURE | BP-30 A

Assignment Unit 30A | Student's Name ______________

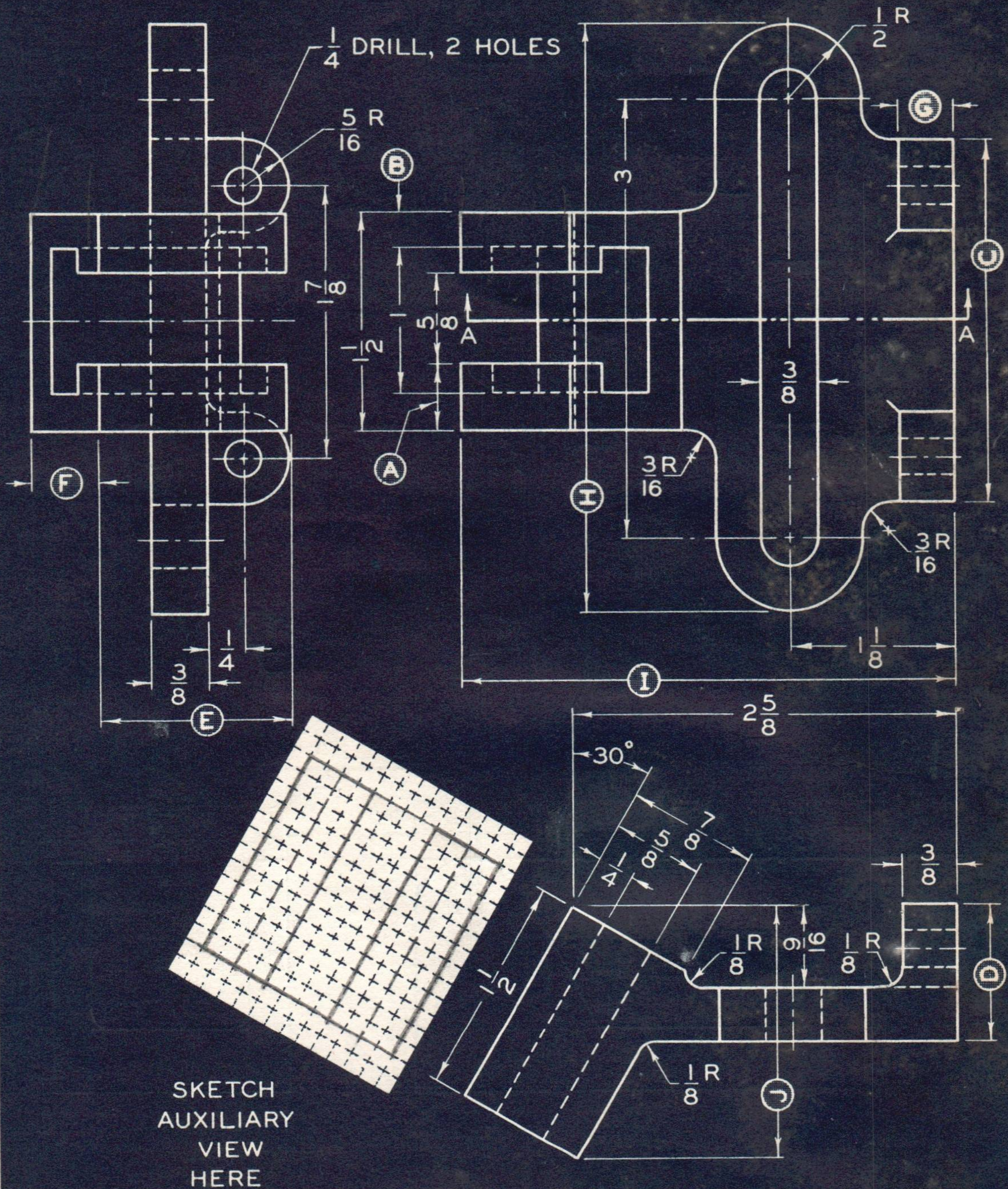


SKETCHING ASSIGNMENT FOR ROCKER FIXTURE

1. MAKE A FREEHAND SKETCH OF THE FRONT AND RIGHT SIDE VIEWS
2. DIMENSION THE VIEWS

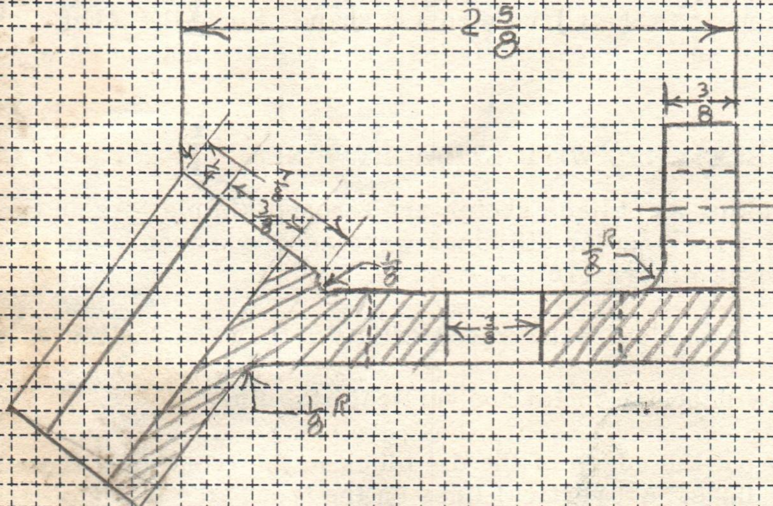
SUGGESTIONS

1. DRAW TO HALF SIZE SCALE (EACH SQUARE= 1/4")


1/4 DRILL, 2 HOLES
5/16 R
1/2 R
3/16 R
3/16 R
1/8 R
1/8 R
1/8 R
30°
2 5/8
SKETCH AUXILIARY VIEW HERE
NO. REQ. 10
ORDER NO. 5-732
MAT'L. CAST STEEL
GUIDE BRACKET
BP-30 B

Assignment Unit **30B**

Student's Name ______________________



SKETCHING ASSIGNMENT FOR GUIDE BRACKET (BP-30B)

1. SKETCH FREEHAND THE REQUIRED AUXILIARY VIEW IN THE SPACE PROVIDED
2. SKETCH FREEHAND AND DIMENSION FULL SECTION VIEW A-A

GUIDE BRACKET (BP-30B)

1. Name each of the three views.
2. Give the number and diameter of the drilled holes.
3. Determine dimensions (A) and (B).
4. Compute dimension (C).
5. What is the dimension of the leg (D)?
6. Compute dimension (E).
7. Give dimension (F) and (G).
8. What is the over all length (H)?
9. Determine over all height (I).
10. Give over all width (J).

1.	front √, leftside, botom √
2.	No. 2 Diam. 1/4
3.	(A) = 5/8 (B) = 1/4
4.	(C) = 2 5/16
5.	(D) = 15/16
6.	(E) = 1 1/2
7.	(F) = 7/8 (G) = 3/8
8.	(H) = 4
9.	(I) = 3 5/16 √ 3 3/8
10.	(J) = 2 3/8 √ 1 3/4

Unit 31 OBLIQUE SKETCHING

Oblique sketches are a type of pictorial drawing on which two or more surfaces are shown at one time on one drawing. The front face of the object is sketched the same way as the front view of either an orthographic sketch or a mechanical drawing. On this front face, all of the straight, inclined and curved lines on the front plane of the object appear in their true size and shape. Since the other sides of the object are sketched at an angle, the surfaces and lines are not shown in their true size and shape.

MAKING OBLIQUE SKETCHES WITH STRAIGHT LINES

The steps in making an oblique sketch are few and simple. As an example, if an oblique sketch of a rectangular die block were needed, seven basic steps would be followed as shown in Figure 116.

STEP 1 ➧ Select one view of the object that gives the most desired information.

STEP 2 ➧ Draw light horizontal and vertical base lines.

STEP 3 ➧ Lay out the edges of the die block in the front view from the base lines. All vertical lines on the front face of the object will be parallel to the vertical base line; the horizontal lines, parallel to the horizontal base line. All lines will be in their true size and shape in this view.

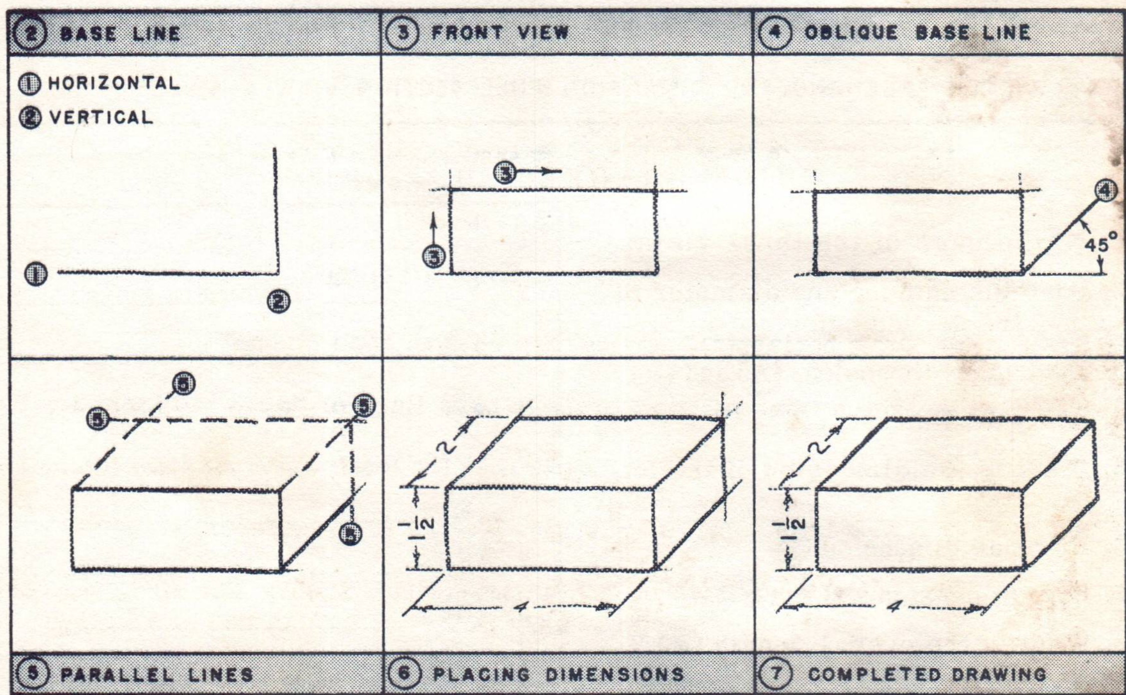


FIG. 116 STEPS IN MAKING AN OBLIQUE SKETCH

STEP 4 ➧ Start at the intersection of the vertical and horizontal base lines and draw a line at an angle of 45° to the base line. This line is called the "oblique base line".

STEP 5 ➧ Draw the remaining lines for the right side and top view parallel to either the oblique base line, or to the horizontal or vertical base lines, as the case may be. Since these lines are not in their true size or shape, they should be drawn so they appear in proportion to the front view.

STEP 6 ➧ Place dimensions so they are parallel to the axis lines.

STEP 7 ➧ Erase unnecessary lines. Darken object lines to make the sketch clearer and easier to interpret.

SKETCHING CIRCLES IN OBLIQUE

A circle or arc located on the front face of an oblique sketch is drawn in its true size and shape. However, since the top and side views are distorted, a circle or arc will be elliptical in these views. An example of how three circles may be drawn in oblique on the top, right side and front of a cube is illustrated in Figure 117.

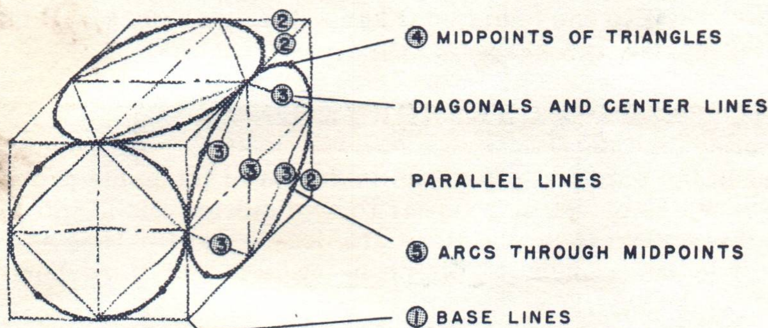


FIG. 117 SKETCHING CIRCLES IN OBLIQUE

STEP 1 ➧ Draw horizontal, vertical and oblique base lines.

STEP 2 ➧ Sketch lines parallel to these base lines or "axes" to form a cube.

STEP 3 ➧ Draw center lines and diagonals in the front, right side and top faces.

STEP 4 ➧ Locate midpoints of triangles formed in three faces.

STEP 5 ➧ Draw curved lines through these points. NOTE: The circle appears in its true size and shape in the front face, and as an ellipse in the right side and top faces.

STEP 6 ➧ Touch up and darken the curved lines and erase guide lines where they are of no value in reading the sketch.

RIGHT AND LEFT OBLIQUE SKETCHES

Up to this point, the object has been viewed from the right side. Many times, the left side of the object is to be sketched because it contains better details. In such cases, the oblique base line or axis is 45° from the horizontal base line starting from the left edge of the object. The same rectangular die block which was sketched from the right side would appear as shown on Figure 118 if the left position were selected.

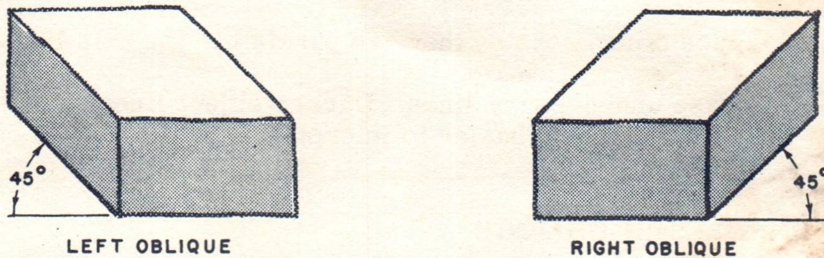


FIG. 118 RIGHT AND LEFT OBLIQUE SKETCHES

The same principles and techniques of making oblique sketches apply regardless of whether or not the object is drawn in the right or left position.

FORESHORTENING

When a line in the side and top views is drawn in the same proportion as lines are in the front view, the object may appear to be distorted and longer than it actually is. To correct this appearance, the lines are drawn shorter than actual size so the sketch of the part looks balanced. This changing is called "foreshortening".

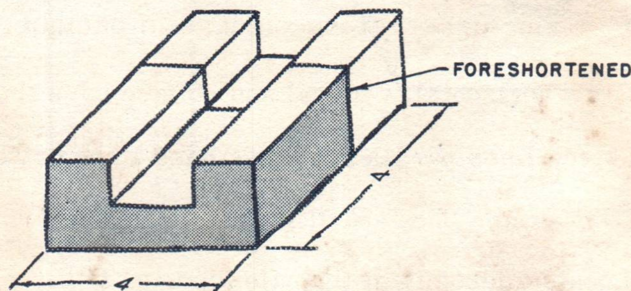


FIG. 119 FORESHORTENING CORRECTS DISTORTION

In Figure 119, the oblique sketches show a part as it would look before and after foreshortening. The foreshortened sketch is preferred. The amount the sketch is foreshortened depends on the ability of the individual to make the sketch resemble the part as closely as possible.

.187 REAM, $\frac{5}{16}$ DEEP, 4 HOLES

$1\frac{5}{8}$ $\frac{3}{16}$ $1\frac{1}{2}$ 2 $\frac{1}{4}$ $3\frac{3}{8}$

$\frac{3}{8}$ $1\frac{1}{4}$ $\frac{3}{8}$ $\frac{3}{16}$ $\frac{1}{2}$

$3\frac{1}{4}$ $\frac{3}{8}$ $\frac{1}{2}$ $\frac{3}{8}$ $\frac{3}{4}$

Assignment Unit 31	Student's Name ________________

SKETCHING ASSIGNMENT FOR V-BLOCK (BP-31)

① MAKE A HALF SIZE FREEHAND OBLIQUE RIGHT SKETCH

② DIMENSION THE SKETCH COMPLETELY

Unit 32 ISOMETRIC SKETCHING

Isometric and oblique sketches are similar in that they are another form of pictorial drawing in which two or more surfaces may be illustrated in one view at one time. The isometric sketch is built around three major lines called isometric base lines or axes (Fig. 120). The isometric base lines form an angle of 30° and the vertical axis line, 90°, with a horizontal base line.

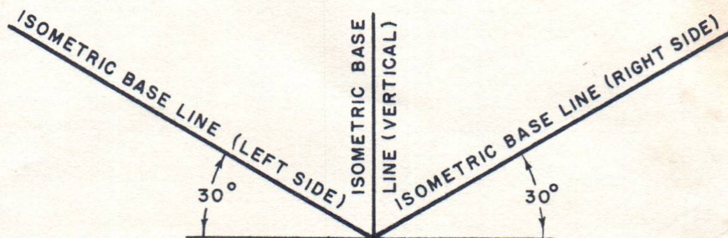


FIG. 120 AXES FOR ISOMETRIC DRAWINGS

MAKING A SIMPLE ISOMETRIC SKETCH

An object is sketched in isometric by positioning it so that the part seems to rest on one corner. The basic steps to follow in making an isometric sketch of a part where all the surfaces or corners are parallel or at right angles to each other are described and illustrated in Figure 121. A rectangular steel block 1" thick, 2" wide, and 3" long is used as an example.

① LAYOUT AXES	② MEASURING ALONG AXES	③ DRAWING PARALLEL LINES	④ DIMENSIONING
30° 30°			1 2 3

FIG. 121 STEPS IN MAKING AN ISOMETRIC SKETCH

STEP 1 ➧ Sketch the three isometric axes. If a ruled isometric sheet is available, select three lines for the major axes.

STEP 2 ➧ Lay off the 3" length along the right axis, the 2" width on the left axis line, and the 1" height on the vertical axis line.

STEP 3 ➧ Draw lines from these layout points parallel to the three axes. Note that all parallel lines on the object are parallel on the sketch.

STEP 4 ➧ Dimension the sketch. On isometric sketches, the dimensions are placed parallel to the edges.

SKETCHING SLANT LINES IN ISOMETRIC

Only those lines that are parallel to the axes may be measured in their true lengths. Slant lines representing inclined surfaces are not shown in their true lengths. In most cases, the slant lines for an object (such as the casting shown in Figure 122) may be drawn by following the steps illustrated in Figure 123.

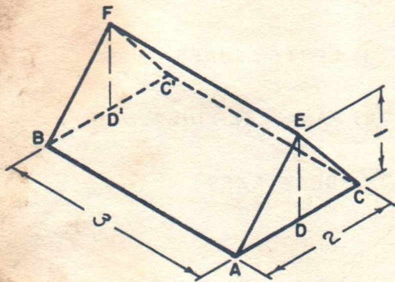


FIG. 122
PART TO BE SKETCHED IN ISOMETRIC

STEP 1 ➧ Draw the three major isometric axes.

STEP 2 ➧ Measure distance AB on the left axis and AC on the right axis.

STEP 3 ➧ Measure distance AD on the right axis and draw a vertical line from this point. Lay out distance DE on this line.

(2) MEASURE SIDES A-B AND A-C
(3) MEASURE HEIGHT D-E
B, E, C, 30°, D, 30°, A

(4) DRAW PARALLEL LINES
F, D', C', E, B, C, D, A

(5) CONNECT POINTS A-E, B-F AND C-E
F, E, B, C, A

(6) DARKEN LINES AND DIMENSION SKETCH
3, 2

FIG. 123 ISOMETRIC SKETCH REQUIRING USE OF SLANT LINES

STEP 4 ➧ Draw parallel lines EF, BC', FD'.

STEP 5 ➧ Connect and darken lines AB, AC, AE, EC, BF and EF.

STEP 6 ➧ Dimension the isometric sketch.

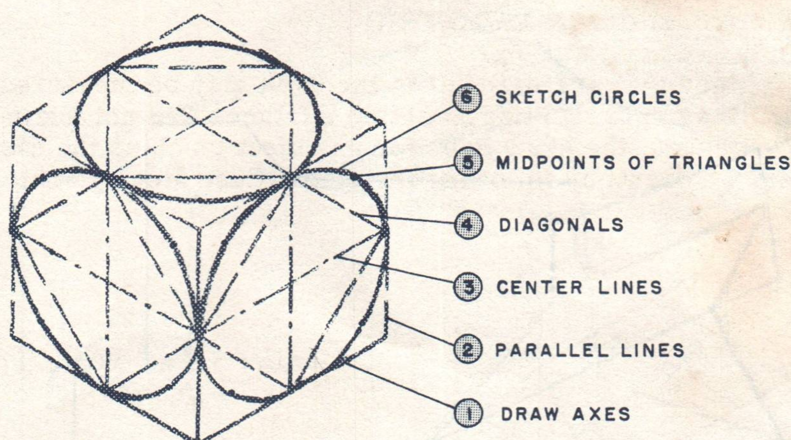


FIG. 124 SKETCHING CIRCLES IN ISOMETRIC

SKETCHING CIRCLES AND ARCS IN ISOMETRIC

The same techniques of sketching arcs and circles in oblique may be used for sketching them in isometric. Each step is illustrated in Figure 124. It should be noted that in each instance the circle appears as an ellipse as further illustrated in Figure 125.

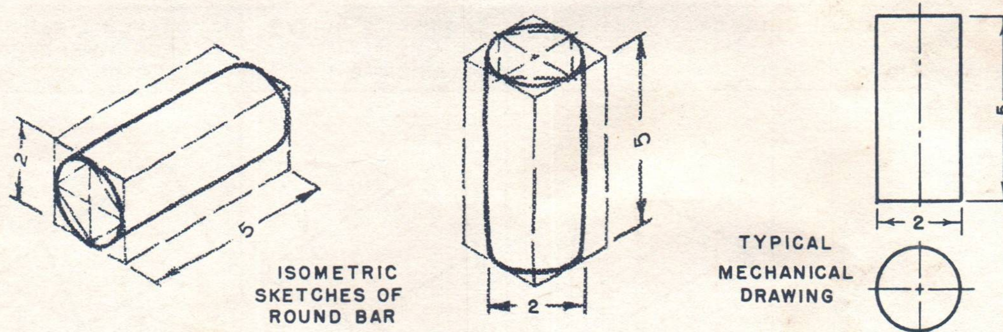


FIG. 125 APPLICATION OF CIRCLES AND ARCS IN ISOMETRIC

LAYOUT SHEETS FOR ISOMETRIC SKETCHES

The making of isometric drawings may be simplified if specially ruled isometric layout sheets are used. Also, considerable time may be saved as these graph sheets provide guide lines which run in three directions, and are parallel to the three isometric axes and to each other. Usually, the diagonal lines are at a given distance apart to simplify the making of the sketch and to insure that all lines are in proportion to the actual size. Sometimes the ruled lines are printed on a heavy paper. In this form, they are used over and over again as an underlay sheet for tracing paper.

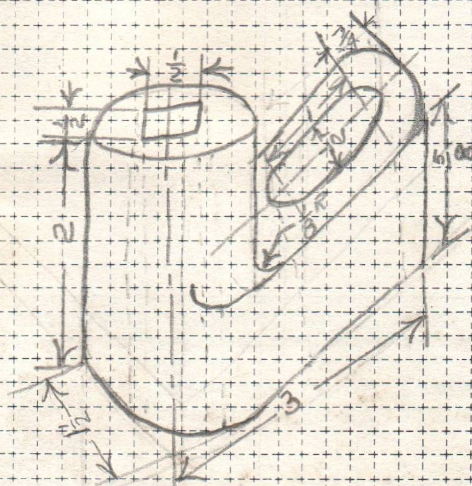
CLUTCH GUIDE	BP-32

MATERIAL

CAST IRON

QUANTITY - 25

Assignment Unit 32	Student's Name



SKETCHING ASSIGNMENT FOR CLUTCH GUIDE (BP-32)

1. MAKE A FREEHAND ISOMETRIC SKETCH OF THE CLUTCH GUIDE
2. DIMENSION THE SKETCH COMPLETELY

Unit 33 PERSPECTIVE SKETCHING

Perspective sketches show either two or three sides of an object in one view. Thus, they resemble a photographic picture. In both the perspective sketch and the photograph, that portion of the object which is closest to the observer is the largest, while the parts that are furthest away are the smallest. Lines and surfaces on perspective sketches become smaller and come closer together as the distance from the eye increases, until eventually they seem to disappear at an imaginary horizon.

SINGLE POINT PARALLEL PERSPECTIVE

The techniques of making two types of perspective sketches, which are most commonly used in the shop, are described in this unit. The first of these is known as "single point" or "parallel perspective". One face of the object in parallel perspective is sketched in its true size and shape, the same as in an orthographic sketch. For example, the edges of the front face of a cube as shown in parallel perspective in Figure 126 at (A), (B), (C) and (D), are parallel and square.

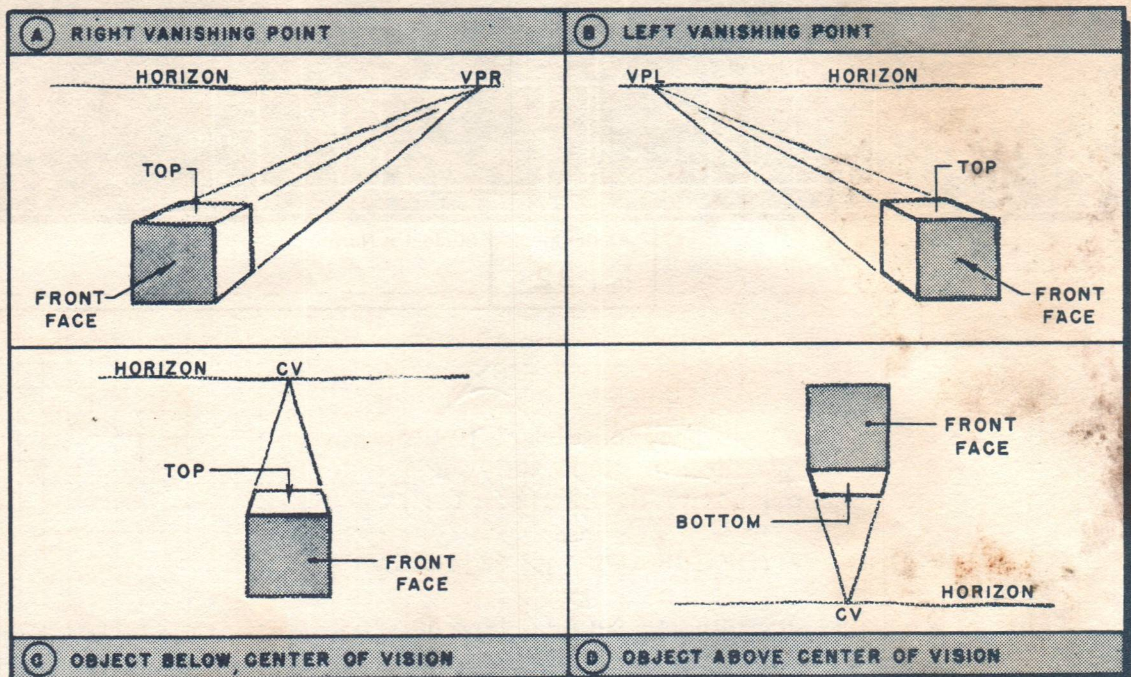


FIG. 126 SINGLE POINT PARALLEL PERSPECTIVE SKETCHES OF A CUBE

To draw the remainder of the cube, the two sides decrease in size as they approach the horizon. On this imaginary horizon, which is supposed to be at eye level, the point where the lines come together is called a "vanishing point". This vanishing point may be above or below the object, or to the right or left of it (Fig. 126). Vertical lines on the object are vertical on parallel perspective sketches and do not converge. Single point parallel perspective is the simplest type of perspective to understand and the easiest to sketch.

ANGULAR OR TWO POINT PERSPECTIVE

The second type of perspective sketch to be covered is the two point perspective, also known as "angular perspective". As the name implies, two vanishing points on the horizon are used and all lines converge toward these points. Usually, in a freehand perspective sketch, the horizon is in a horizontal position. Seven basic steps which are followed to make a two point perspective of a cube, using right and left vanishing points, are described in detail. The application of each of these steps is made in Figure 127.

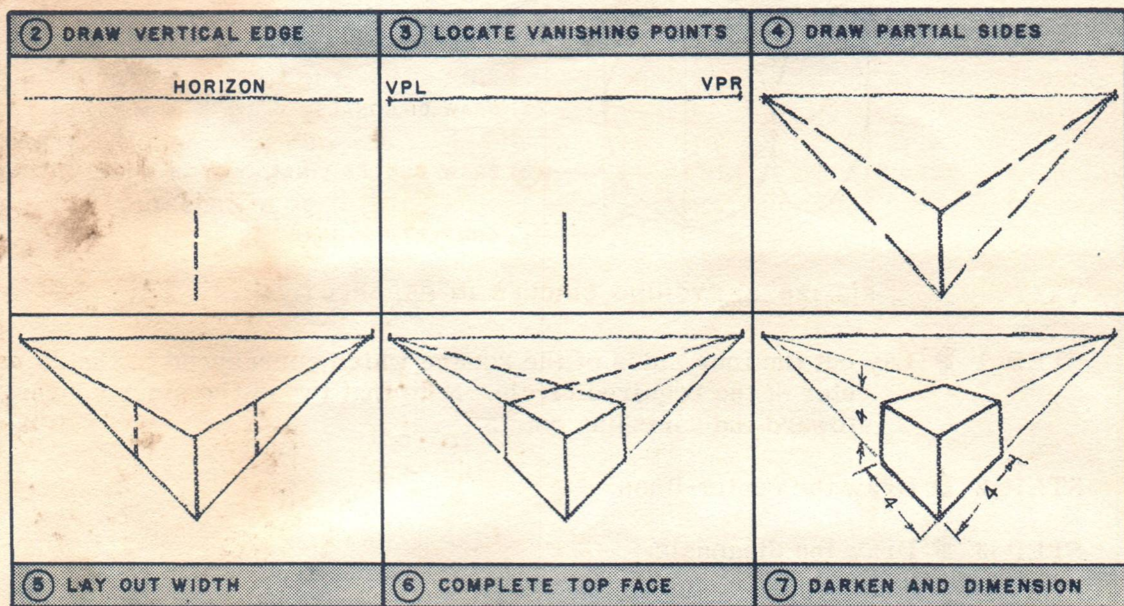


FIG. 127 MAKING AN ANGULAR PERSPECTIVE SKETCH OF A CUBE

STEP 1 ➧ Sketch a light horizontal line for the horizon. Then position the object above or below this line so the right vertical edge of the cube becomes the center of the sketch.

STEP 2 ➧ Draw a vertical line for this edge of the cube.

STEP 3 ➧ Place two vanishing points on the horizon: one to the right and the other to the left of the object.

STEP 4 ➧ Draw light lines from the corners of the vertical line to the vanishing points.

STEP 5 ➧ Lay out the width of the cube and draw parallel vertical lines.

STEP 6 ➧ Sketch the two remaining lines for the top, starting at the points where the two vertical lines intersect the top edge of the cube.

STEP 7 ➧ Darken all object lines and dimension. Once again, each dimension is placed parallel to the edge which it measures.

SKETCHING CIRCLES AND ARCS IN PERSPECTIVE

Circles and arcs are distorted in all views of perspective drawings except in one face of a parallel perspective drawing. Circles are drawn in perspective, using the same techniques of blocking-in which apply to orthographic, oblique and isometric sketches. The steps in drawing circles in perspective are summarized in Figure 128. The same practice may be applied to sketching arcs.

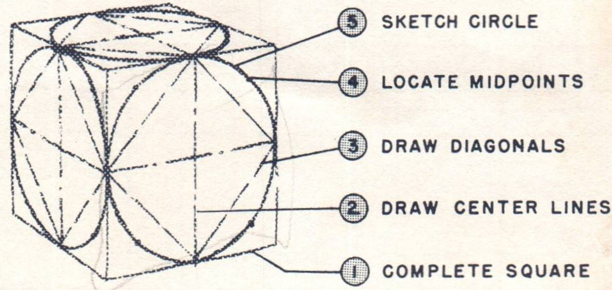


FIG. 128 SKETCHING CIRCLES IN PERSPECTIVE

STEP 1 ➧ Lay out the four sides of the square which correspond to the diameter of the required circle. Note that two of the sides converge toward the vanishing point.

STEP 2 ➧ Draw the center lines.

STEP 3 ➧ Draw the diagonals.

STEP 4 ➧ Locate the midpoints of the triangles which are formed.

STEP 5 ➧ Sketch the circle through the points where the center lines touch the sides of the square and the midpoints.

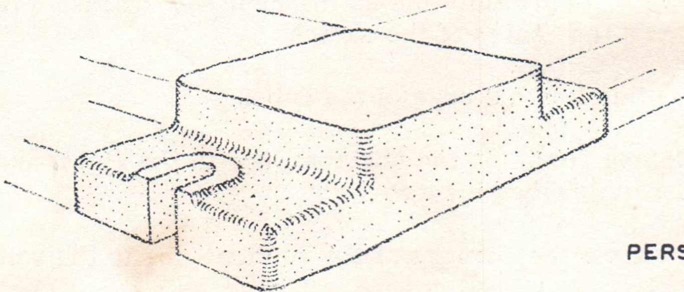


FIG. 129

SHADING APPLIED TO PERSPECTIVE SKETCH OF DIE BLOCK

SHADING PERSPECTIVE SKETCHES

Many perspective sketches are made of parts which include fillets, rounds, chamfers and similar construction. By bringing out some of these details, the drawing is made easier to read and is more attractive. The same techniques that are used for shading regular mechanical drawings or other pictorial sketches may be applied to perspective drawings, to bring out some of the construction details which otherwise might not be included.

Assignment Unit 33

Student's Name

①

VPL VPR

SLIDE BLOCK

②

$\frac{3}{8}$ DRILL, $\frac{9}{16}$ C'BORE, $\frac{1}{4}$ DEEP, 2 HOLES

VPL

SECTION A-A

SKETCHING ASSIGNMENT ON PARALLEL PERSPECTIVE (BP-33)

1. COMPLETE FREEHAND THE ANGULAR PERSPECTIVE SKETCH OF THE SLIDE BLOCK
2. MAKE A FREEHAND PARALLEL PERSPECTIVE SKETCH OF SECTION A-A OF THE FIXTURE BASE. NOTE: USE THE GIVEN STARTING POINTS
3. SHOW CROSS-SECTION LINES, SHADE TO SHOW FILLETS, AND DIMENSION

Appendix



INDEX

467 (6C829)